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Biometric Identification/Verification Brassboard Proof-of-Concept System
Phase II

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Technical Report

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13. ABSTRACT (Maximum 200 words)

DoD budget and personnel reductions drive requirements for an entry/access control system capable of non-intrusively identifying and verifying the identity of persons with a high degree of confidence and without a man in the decision loop. Operational Performance Requirements (OPR) were assembled from the SOW and Service requirements documents. An Iris-Based Biometric Identification/Verification Brassboard Proof-of-Concept System was designed and fabricated. The system was tested in accordance with the DNA-approved Test Plan and demonstrated at three sites. The test started with a database of 405 files and provided for enrollment of 160 added IrisCodes. Fifty verifications and 1,944 identifications averaged 2.44 seconds each, with a False Accept Rate of 0. One hundred fifty impostor irises and 662 unenrolled irises were correctly rejected; one enrolled person wearing dirty glasses was incorrectly rejected, for a False Reject Rate of .05%. (The rejected enrollee was identified on second and all subsequent attempts, both with and without glasses.) Average enrollment time was 25 seconds, plus typing time. The system made 3,100,000 file comparisons without error. The system met or exceeded all test standards and requirements.

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EXECUTIVE SUMMARY

There is a need within the Department of Defense (DoD) to provide an entry/access control system capable of identifying and verifying the identity of persons with a high degree of confidence and without a man in the loop. In support of this requirement, the Defense Nuclear Agency (DNA) reached a preliminary conclusion as to the most promising technology to pursue, and initiated a study effort to confirm or refute their conclusion, and to determine the feasibility of developing the selected system. The study, published as DNA-TR-94-6, September 1994, found no system, technology, or methodology which can meet all of the objectives and requirements specified in the Statement of Work (SOW). Of the systems, technologies, and methodologies under development, only the IriScan system of positive identification / verification, using an iris recognition process, appears capable, with further development, of meeting those objectives and OPRs. DNA then issued a Contract Modification exercising Option One (Phase II) for fabrication, testing and reporting on an iris-based Brassboard Proof-of-Concept Identification/Verification System. The IriScan Brassboard Test confirmed that:

- The system started with a database of 405 IrisCodes and enrolled 160 irises.
- The system effectively and accurately performed identification and verification (1,944 identifications and 50 verifications in an average of 2.44 seconds each, without error, with a False Accept rate of 0).
- The system effectively and accurately rejected impostors and persons not enrolled (662 un-enrolled irises and 150 impostor irises were correctly rejected, while one enrolled person wearing dirty glasses was incorrectly rejected, for a False Reject rate of .05%) (rejected enrollee learned to control eyeglass reflections and was identified on second and subsequent attempts, both with and without glasses).
- All subjects were enrolled. Average time was 25 seconds, plus typing time.
- The user alignment, accept/reject light and audible signal systems worked effectively and reliably, without negative comment by users.
- Dark eyes were handled with virtually identical speed and accuracy as others.
- The system made 3,100,000 file comparisons without error. There was one human image-acquisition error (resulting in the False Reject).
- The DNA Brassboard System met or exceeded all test standards / requirements.

PREFACE

Permission was provided by the Institute of Electrical and Electronics Engineers, Inc. (IEEE), for republication of the paper, High Confidence Visual Recognition of Persons by a Test of Statistical Independence, at Appendix D.

CONVERSION TABLE

Conversion factors for U.S. Customary to metric (SI) units of measurement.

MULTIPLY ⟶ **BY** ⟶ **TO GET**
TO GET ⟵ **BY** ⟵ **DIVIDE**

angstrom	1.000 000 X E -10	meters (m)
atmosphere (normal)	1.013 25 X E +2	kilo pascal (kPa)
bar	1.000 000 X E +2	kilo pascal (kPa)
barn	1.000 000 X E -28	meter^2 (m^2)
British thermal unit (thermochemical)	1.054 350 X E +3	joule (J)
calorie (thermochemical)	4.184 000	joule (J)
cal (thermochemical/cm^2)	4.184 000 X E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000 X E +1	*giga becquerel (GBq)
degree (angle)	1.745 329 X E -2	radian (rad)
degree Fahrenheit	$t_k = (t^{\circ}f + 459.67)/1.8$	degree kelvin (K)
electron volt	1.602 19 X E -19	joule (J)
erg	1.000 000 X E -7	joule (J)
erg/second	1.000 000 X E -7	watt (W)
foot	3.048 000 X E -1	meter (m)
foot-pound-force	1.355 818	joule (J)
gallon (U.S. liquid)	3.785 412 X E -3	meter^3 (m^3)
inch	2.540 000 X E -2	meter (m)
jerk	1.000 000 X E +9	joule (J)
joule/kilogram (J/kg) radiation dose absorbed	1.000 000	Gray (Gy)
kilotons	4.183	terajoules
kip (1000 lbf)	4.448 222 X E +3	newton (N)
kip/inch^2 (ksi)	6.894 757 X E +3	kilo pascal (kPa)
ktap	1.000 000 X E +2	newton-second/m^2 (N-s/m^2)
micron	1.000 000 X E -6	meter (m)
mil	2.540 000 X E -5	meter (m)
mile (international)	1.609 344 X E +3	meter (m)
ounce	2.834 952 X E -2	kilogram (kg)
pound-force (lbs avoirdupois)	4.448 222	newton (N)
pound-force inch	1.129 848 X E -1	newton-meter (N·m)
pound-force/inch	1.751 268 X E +2	newton/meter (N/m)
pound-force/foot^2	4.788 026 X E -2	kilo pascal (kPa)
pound-force/inch^2 (psi)	6.894 757	kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924 X E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011 X E -2	kilogram-meter^2 (kg·m^2)
pound-mass/foot^3	1.601 846 X E +1	kilogram/meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000 X E -2	**Gray (Gy)
roentgen	2.579 760 X E -4	coulomb/kilogram (C/kg)
shake	1.000 000 X E -8	second (s)
slug	1.459 390 X E +1	kilogram (kg)
torr (mm Hg, 0° C)	1.333 22 X E -1	kilo pascal (kPa)

*The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.
**The Gray (GY) is the SI unit of absorbed radiation.

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SECTION 1

INTRODUCTION

1.1 GENERAL.

Efficient and effective protection of assets, information and people at low cost is becoming increasingly important as governmental and organizational budgets are cut while internal and external threats continue to increase. Additionally, the escalation of violence in the workplace and the spiral of legal actions resulting from perceived security shortfalls have raised the sensitivity of facility owners and managers to access control issues. Effective access control requires positive personal identification.

1.2 BACKGROUND.

Currently available personnel identification / verification and entry control systems, biometric and non-biometric, have not yet been able to meet all operational requirements. They are generally manpower intensive, costly to procure and maintain, frequently unreliable, and sometimes slow in identifying individuals and verifying approved access. However, significant research and development in the field of biometric identification continues.

On the basis of proposals and initial research, the Defense Nuclear Agency (DNA) contracted IriScan Inc. on July 19, 1993, to conduct a study to evaluate current and developing biometric identification technologies. This study was initiated to determine the feasibility of developing an identification / verification system capable of positively identifying and verifying individuals without physical contact and without a person in the decision loop. During the study, 17 biometric identification systems currently or previously marketed, and 18 biometric identification research and development projects currently underway were investigated. The study verified that iris-based identification /

verification technology was most likely to meet the operational requirements in the near term. Upon delivery of the study report (Phase I Final Report), DNA issued a contract modification exercising Option One (Phase II).

Phase II included three Tasks:

> Task I required the development and fabrication of a brassboard proof-of-concept iris-based biometric identification / verification system. The resulting system must be documented with developmental drawings in accordance with DoD-MIL-T-31000. An updated cost estimate for a deployable system must also be provided.
>
> Task II required the development of a plan for testing the brassboard proof-of-concept system, and DNA approval of that plan. The plan included methodologies to evaluate and verify system performance in meeting the requirements identified in the contract Statement of Work.
>
> Task III required performance of the brassboard proof-of-concept test in accordance with the Test Plan, collection and analysis of the test data, and development of a Test Report documenting the test results. Additionally, a brassboard proof-of-concept system performance demonstration was to be conducted at a time and location designated or approved by the DNA Program Manager. (This occurred November 21-22, 1994 at DNA Headquarters.)

1.3 THE REPORT.

This report transmits the information and documents required under Option One (Phase II) of the contract.

SECTION 2

TEST PLAN

2.1 THE TASK.

Phase II, Task II required development of a Draft Test Plan for the Brassboard Proof-of-Concept Identification /Verification System. The plan must include the methodology to evaluate and verify the performance of the identification / verification system in satisfying the requirements identified in Task I of Phase I of the contract. Upon DNA Program Manager approval of the Draft, the Test Plan becomes Final.

2.2 PERFORMANCE.

The Test Plan was developed in two stages. The Draft Generic Test Plan for the Brassboard Proof-of-Concept Identification /Verification System was published on April 26, 1994, and delivered to the DNA Program Manager on April 29, 1994. On June 1, 1994, the DNA Program Manager provided verbal concurrence with the Draft Generic Test Plan.

The Draft Test Plan for the Brassboard Proof-of-Concept Identification /Verification System was published on September 12, 1994, and provided to the DNA Program Manger. He provided informal comments on the Draft Test Plan on October 3, 1994. The comments were integrated into the draft and the Test Plan for the Brassboard Proof-of-Concept Identification /Verification System was published on October 7, 1994.

2.3 THE TEST PLAN.

A copy of the Test Plan for the Brassboard Proof-of-Concept Identification /Verification System is at Appendix A.

SECTION 3

TEST REPORT

3.1 THE TASK.

Phase II, Task III required performance of a brassboard proof-of-concept test, collection and analysis of the test data, and development of a Test Report documenting the test results.

3.2 PERFORMANCE.

In accordance with the Test Plan, a Pre-Test was conducted to confirm that the test procedures, forms, and automated data-collection software were effective in compiling all of the data necessary to meet test requirements. The Pre-Test was initiated on October 12, 1994. It continued while necessary data-collection software modifications were installed and tested and was terminated on October 19, 1994.

The DNA Brassboard Iris-Based Biometric Identification Proof-of-Concept System Test was initiated on October 21, 1994. From that date until test termination, all system activities, including enrollments, identifications and rejections, were recorded. The Test was terminated at noon on November 16, 1994.

The majority of the test activities were conducted at the IriScan laboratory, 133-Q Gaither Drive, Mt. Laurel, New Jersey. Two days of testing were conducted at the American Correctional Association (New Jersey Chapter) Exhibits at the Hilton Hotel, Long Branch, New Jersey, for the purposes of expanding live-eye testing and increasing the size of the database. Lt. Col. Johnnie J. Gore, DNA Program Manager observed and participated in test activities on October 27, 1994. Mr. Thomas J. Whittle, PE, DNA Technical Advisor, observed and participated in test activities on November 2, 1994.

The test data were collated, analyzed and summarized and the Draft Test Report prepared. The report also includes all of the data collected during the test period. The Draft Test Report was delivered to the DNA Program Manager on December 20, 1994. Two informal comments were received on January 5, 1995, and the Final Test Report was prepared.

3.3 THE TEST REPORT.

The Brassboard Iris-Based Biometric Identification /Verification System Proof-of-Concept Test Report is at Appendix B.

Briefly synopsized, the test results were:

- The test started with a database of 405 IrisCodes. An additional 160 irises were enrolled during the test.
- The system effectively and accurately performed identification and verification (1,944 identifications and 50 verifications in an average of 2.44 seconds each, without error, with a False Accept rate of 0).
- The system effectively and accurately rejected impostors and persons not enrolled (662 un-enrolled irises and 150 impostor irises were correctly rejected, while one enrolled person wearing dirty glasses was incorrectly rejected, for a False Reject rate of .05%) (rejected enrollee learned to control eyeglass reflections and was identified on second and subsequent attempts, both with and without glasses).
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- The DNA Brassboard System met or exceeded all test standards / requirements.

SECTION 4

BRASSBOARD SYSTEM DEMONSTRATION

4.1 THE TASK.

Phase II, Task III required that a Brassboard Proof-of-Concept System performance demonstration be conducted at a time and location designated or approved by the DNA Program Manager.

4.2 PERFORMANCE.

The Brassboard Proof-of-Concept System Demonstration was held at DNA Headquarters on November 21-22, 1994. The system was set up in the main conference room from 9:30 am until 3:00 pm on Monday and from 9:00 am until 2:00 pm on Tuesday. Program support personnel present included Mr. John E. Siedlarz, CEO, IriScan, Inc.; Mr. Cletus B. Kuhla, IriScan Technical Director; Mr. James T. McHugh, IriScan Senior Engineer; Mr. Gerald O. Williams, IriScan Senior Analyst; and Mr. Donald R. Richards, IriScan DNA Program Manager. Lt. Col. Johnnie J. Gore, DNA Brassboard Program Manager was also present for all of the demonstrations.

DNA invited representatives from various government agencies to observe / participate in the demonstrations. Fifty individuals from DNA, Central Intelligence Agency, US Army INSCOM, Office of the Secretary of Defense, Computer Sciences Corp., US Navy Director for Strategic Systems, Vitro Corp., US Air Force Security Plans & Programs, Department of State, Horizons Technology Inc., Department of Energy, and the US Army Physical Security Equipment Management Office attended and \ or participated.

The Brassboard Proof-of-Concept System performed accurately and without failure. DNA representatives stated that they were well satisfied with the demonstration.

SECTION 5

DOCUMENTATION

5.1 THE TASK.

Contract Statement of Work (SOW), para 4.0, Deliverables, subparagraph 6, Proof-of-Concept System Documentation, requires the submittal of unspecified documentation.

5.2 PERFORMANCE.

In addition to the requested drawings and DoD System Cost Estimate which follow, an IriScan Functional Description and Brassboard Operational Procedures have been included at Appendices C and E, respectively.

5.3 IRISCAN FUNCTIONAL DESCRIPTION.

The functional description of the IriScan Biometric Identification System includes generic cataloging of the primary hardware modules plus a narrative explanation of how the IriScan process works. The mathematical theory and calculations involved in the process are covered Dr. John Daugman's IEEE paper, "High Confidence Personal Identification By Rapid Video Analysis of Iris Texture," included as Appendix D.

5.4 BRASSBOARD OPERATIONAL PROCEDURES.

The operational procedures provided are based on those procedures developed for the Brassboard Proof-of-Concept Test, and thus contain procedures for logging and documentation of test results. While this may not be wholly relevant, little is known about the future applications envisioned for the Brassboard unit, and these procedures can be modified accordingly.

SECTION 6

DRAWINGS

6.1 THE TASK.

Phase II, Task I required that the Brassboard Proof-of-Concept System be documented with developmental drawings in accordance with DoD-MIL-T-31000.

6.2 PERFORMANCE.

Several steps are required in order to plan, design, fabricate parts, and manufacture an electronic system. Several kinds of drawings are utilized in these steps. In the case of the DNA Brassboard Proof-of-Concept System these include:

System Block Diagram,
Concept Assembly Drawing,
Board Layout Drawing,
Board Fabrication Drawing,
Wiring Diagrams (3), and
System Parts Drawings (28).

6.3 THE DRAWINGS.

The thirty-five drawings identified above are provided at Appendix F.

SECTION 7

DOD SYSTEM COST ESTIMATE

7.1 THE TASK.

Phase II, Task I required the documentation of the results of the Prototype Development with drawings and updated cost estimates.

7.2 PERFORMANCE.

The cost estimates in Appendix G are based on actual quotes from parts and equipment manufacturers, some of whom provided parts, equipment, and engineering services to IriScan for fabrication of the Brassboard unit. They are based on ordering in quantities of 1000 because that was the smallest quantity at which significant cost savings could be realized. Quotes for quantities of 500 or less, would result in increased prices in the range of $500-$1,000, or more, per unit. Some of the factors which could affect the ultimate system cost are identified and discussed below.

7.3 REDESIGN.

The DNA Brassboard Proof-of-Concept System designed, fabricated, tested and demonstrated, met the requirements of the SOW. However, as this report is being compiled, significant redesign of the commercial version of the iris identification device is underway. Essentially, for the Access / Entry Control application, the unit will likely be split into two modules, the Computational Platform, and the Optical Platform. The computational platform will be located inside the secure area and only the optical platform will be visible outside the secure area at the controlled portal. Reducing the size of the IriScan-unique portion of the unit (the Optical Platform) and use of a

standard NEMA box to house the Computational Platform may thus have minor impact on the costs of the enclosures.

7.4 SUPPORT SYSTEM SOFTWARE.

There is no Support System (administrative) software currently available for either the commercial or the DNA Brassboard models of the iris identification / verification system. Those functions of linking multiple doors, sharing a common communications network, determining access levels for an entrant, opening doors, reporting status and events to a central monitoring agency, and providing historical reports are not now available. These must be developed, engineered, tested, and approved, at some cost. The estimated "up front" Non-Recurring Engineering (NRE) costs to develop this software are prorated across a 1,000 unit production run.

Because of the increased security of the two-module configuration of the IriScan system, this is the unit that would be recommended for DoD utilization. If application of further R & D funding (6.3) was considered, availability of Service-desired capability units (such as exterior operations) could be advanced.

7.5 SYSTEM INTERFACE.

Costs of interfacing the Brassboard unit with existing or "defined-but-not-procured" DoD systems are unknown, but could be treated in the same manner as Support System Software Development costs. Some of the issues involve the nature of the output of the iris identification device, (e.g., does the device simply provide an IriScan IrisCode number to the host and allow the host to use a look-up table to convert to the entrant's Wiegand file number, or should a look-up table be embedded in the iris unit, so as to provide a Wiegand output?). Another issue is the extent to which entrance is granted by the Support System Software of the iris identification system vs. the host system.

Finally, to what extent does the iris identification unit provide an alarm output beyond the tamper alarm resident therein?

7.6 COSTS OVER TIME.

Unlike most products and equipment, the cost of general purpose PC chips is declining. The current cost of the DX4 may decline dramatically when Intel introduces the next future-generation chip. Countering that trend is the "planned obsolescence" which, at some point in time may make procurement of a DX4 system impossible. Absent some financially rewarding incentive, producers of the DX4 will, in the future, undoubtedly cease production and provide only next-generation chips or their successor(s).

SECTION 8

CONCLUSIONS AND LESSONS LEARNED

Phase I resulted in the evaluation of all biometric identification / verification systems in the marketplace and those that could be located in research and development programs, to determine which ones could potentially meet certain standards and requirements. The Phase I Final Report confirmed the government's selection of iris-recognition technology as the most viable candidate. Phase II covered the design, fabrication and assembly of a proof-of-concept system, and the testing and demonstration of that system.

The DNA Iris-Based Brassboard Proof-of-Concept System designed and built under this contract met or exceeded all standards and Operational Performance Requirements specified in the Test Plan and the contract Statement of Work (SOW).

Further, the DNA Iris-Based Brassboard Proof-of-Concept System (hereafter termed Brassboard) was successfully demonstrated at the Headquarters of the Defense Nuclear Agency, the US Air Force Electronic Systems Command (ESC) at Hanscom Air Force Base, and the Security Equipment Integration Working Group (SEIWG), during the November 1994 through January 1995 period.

The DNA Brassboard Test and Demonstrations have confirmed that the system is user-friendly and easy to effectively utilize. No extraordinary training was employed; in fact, nearly all users were successful after less than one minute of demonstration and explanation of the system.

The estimated costs for a DoD system are reasonable and cost-effective, especially when compared to the cost and performance of other biometric identification / verification access control systems now available in the marketplace.

The standards and requirements contained in the contract SOW were:

- System capable of operating in verification or identification mode.
- Type I (False Reject) Error < 1%.
- Type II (False Accept) Error < .1 %.
- Unique physical characteristic as identifier.
- No known counterfeiting techniques for the physical characteristic.
- System usable by maximum percentage of potential user population.
- State-of-the-art technology.
- Non-invasive sampling (no fingerprint, palmprint, retina scan, blood or other fluids).
- No person in the decision loop.
- No person-equipment contact for data collection.
- Average identification / verification in less than 5 seconds, including false reject re-reads.
- Easily understood visual and / or audible feedback for alignment.
- Visual and / or audible indication of acceptance or rejection.
- User friendly, no formal training required.
- Stand-alone system capability required.
- Local database of 40,000 enrollees desired.
- Multiple portal controllers can be connected to central database.
- Compatible with existing commercial and military access control systems.
- Enrollment in less than two minutes, excluding administrative data entry.
- System operating humidity up to 95 %. (NT = Not Tested)
- System operating temperatures from 0 to 65 degrees, centigrade. (NT)
- Initially an indoor system; but no intrinsic hindrance to outdoor operations.
- Mean Time Between Failures (MTBF) goal is 10,000 hours. (NT)
- Mean Time to Repair (MTTR) to be no more than one hour. (NT)
- Sensor assembly not to exceed 24" x 24" x 12" and thirty pounds.
- Single portal system production unit cost goal of $5,000 or less.

The iris-based biometric access control system appears to be a viable candidate to meet the DoD field requirements of the near future. However, several steps remain before it could be deployed as part of the Services' entry control systems:

- Detailed definition of the iris-based identification system interface with the Services' entry control systems.

- Final design of the iris-based identification system compatible with the Services' entry control systems.

- Development of Operational Procedures and technical documentation in accordance with military requirements.

- Manufacturing of the specified iris-based identification system.

- Testing of the iris-based identification system as an integral part of the Services' entry control systems.

- Development of capability for exterior or mobile operations, if desired.

APPENDIX A

TEST PLAN

for

DEFENSE NUCLEAR AGENCY

BRASSBOARD IDENTIFICATION / VERIFICATION SYSTEM

1.0 INTRODUCTION.

1.1 Background. The Defense Nuclear Agency (DNA) has contracted IriScan Inc. to design and construct a brassboard proof-of-concept biometric identification / verification system. The contract also requires development of a Test Plan, which is to be approved by DNA, and the testing of the brassboard system in accordance with the Test Plan.

1.2 Purpose. The purpose of this Test Plan is to define test objectives, develop evaluation criteria, identify and define the test bed, and to provide a test POA&M.

1.3 Testing methodology. Some distinction should be made between items to be tested, items to be demonstrated, and items to be analyzed. Of those Phase II (Option I) outcomes agreed upon, some are appropriate only to testing, and others are appropriate only to demonstration or analysis. For example, the effectiveness of the user alignment system will be demonstrated thoroughly by virtue of the identification, verification, and rejection testing specified in the test objectives below. Demonstration of Type I and Type II error rates is possible only if DNA officials are present over an extended period. Given that this is not a practical approach, the "demonstration" of Type I and Type II error rates will be accomplished by providing the test results and analyses to DNA. Table 1 divides Phase II outcomes into what we perceive are appropriate categories at this point in Test Plan development.

TABLE 1: QUALIFICATION METHODOLOGY

PARAMETER	T	D	A	I	COMMENT
User Alignment		X			
Accept / Reject Lights		X			
Audible Sound		X			
Verification		X			
Identification		X			
Type I Error Rate	X				
Type II Error Rate	X				
Verification ≤ 5 seconds	X				
Identification ≤ 5 seconds	X				
Enrollment ≤ 2 minutes	X				
Four Hundred Files		X			
Enroll/Recognition of Dark Eyes		X			
40,000 File Database			X		
Central Database Interface			X		

QUALIFICATION METHODS

TEST Test is a method of verification through systematic exercising of the equipment under all applicable conditions, with instrumentation and the collection / analysis / evaluation of quantitative data.

DEMONSTRATION Demonstration is a method of verification involving the operation, movement, or adjustment of an item and the comparison of the item performance against a qualitative standard.

ANALYSIS Analysis is a method of verification involving the evaluation of theoretical or empirical data or both. Such data may be in the form of equations, charts, graphs, tables, calculations, or representative data.

INSPECTION Inspection is a method of verification involving examination of an item and the comparison of pertinent characteristics against a predetermined qualitative or quantitative standard. Inspection may require moving or partially disassembling the item to accomplish the verification.

2.0 PROOF OF CONCEPT TEST OBJECTIVES. The overall objective of this test is to determine whether or not iris identification technology (and the IriScan patented process, specifically) can provide a system which is capable, at least conceptually, of identifying and verifying individuals without the aid of a person in the decision loop and without requiring physical contact between the system and the individuals.

2.1 Identification. The test should confirm the ability of the system to identify individuals by comparing a presented iris with records of enrolled irises in a database.

2.2 Verification. The test should confirm the ability of the system to verify a person's identity by comparing a presented iris with a specific, designated iriscode file resident in the system's database.

2.3 Rejection. The test should confirm the ability of the system to reject users when the presented iris does not match any iriscode in the database (identification mode), or the presented iris does not match the specifically designated iriscode resident in the database (verification mode).

2.4 User Alignment. The test should demonstrate the ability of the system to provide sufficient feedback to allow a user to properly align him/herself so that useable iris images can be obtained for processing.

2.5 Accept/Reject Lights. The test should confirm the ability of the system to provide visual indication that a user's entry attempt has been accepted or rejected.

2.6 Audible Signal. The test should confirm the ability of the system to provide audible indication that a user's entry attempt has been accepted or rejected.

2.7 Identification ≤ 5 seconds. The test should confirm the ability of the system to identify (recognize) a person (match a presented iris with the users' file in an enrolled database) in less than 5 seconds, average, given a database of 4,000 iriscodes.

2.8 Verification ≤ 5 seconds. The test should confirm the ability of the system to verify a person's identity (match a presented iris with a specifically designated file in an enrolled database) in less than 5 seconds, average.

2.9 Enrollment ≤ 2 minutes. The test should confirm the ability of the system to enroll persons into the iriscode database in less than two minutes, on average.

2.10 Type I errors ≤ 1%. The test should confirm that the False Reject rate is equal to or less than 1% (one per hundred).

2.11 Type II errors ≤ .1%. The test should confirm that the False Accept rate is equal to or less than .1% (one per thousand).

2.12 Four Hundred Files. The test should demonstrate the presence of at least four hundred different iriscodes in the database.

2.13 Enrollment / Recognition of Dark Eyes. The test should demonstrate the presence of dark eyes (brown) in the database and the ability of persons with dark eyes to be enrolled, identified and verified.

2.14 40,000 File Database. The test should allow evaluators to analyze the system capacity to ensure that 40,000 iriscodes could be entered into the database.

2.15 Central Database Interface. The test should allow evaluators to analyze the system to verify that there is a communication port physically and electronically capable of interfacing with a central database.

3.0 EVALUATION CRITERIA.

3.1 Identification. When an authorized user (known authentic) presents his/her iris at the iris reader, there are three possible outcomes. The system can correctly identify the individual and so indicate by audible and visual signals; the system can reject the individual and so indicate; or the system can fail. Failure can be defined as the inability of the system to identify or reject an individual in one minute. With a known authentic, a trial that results in a correct identification shall be a successful trial. A trial that results in rejection or system failure shall be a failure unless that failure can be positively attributed to excessive head rotation, power failure, or some other identifiable phenomenon. Identification will be thoroughly tested during the sequences for determining Type I and Type II errors.

3.2 Verification. When an authorized user (known authentic) enters a Personal Identification Number (PIN) by use of the system keyboard and then presents his/her iris at the iris reader, there are three possible outcomes. The system can correctly identify the individual and so indicate by audible and visual signals; the system can reject the individual and so indicate; or the system can fail. Failure can be defined as the inability of the system to identify or reject an individual in one minute. With a known authentic, a trial that results in a verification shall be a successful trial. A trial that results in rejection or system failure shall be a failure unless that failure can be positively attributed to use of an incorrect PIN, power failure, or some other identifiable phenomenon. Verification will be thoroughly tested during the sequences for determining Type I and Type II errors.

3.3 Rejection. This test can be run concurrent with Type II error (False Accept) testing in both the identification and verification mode. A successful trial is one in which a known imposter (someone who is not enrolled in the database, or someone who deliberately uses an incorrect PIN) presents his/her iris and the system rejects the individual by lighting the Reject Light and providing an appropriate audible signal. A failure is a trial that results in a rejection, but one or the other of the indicators fails to respond. If a subsequent lamp or

audio test confirms mechanical failure, the trial shall not be a failure, and shall be disregarded.

3.4 User Alignment. The demonstration of an effective user alignment system will be an inherent part of the testing scenarios which follow. Evaluation of the success of this demonstration will be based on observation by testers and evaluators of the ease with which users who have been trained and enrolled in the system can subsequently identify or verify. Although there will be no time criteria, the user should be able to place him/herself in position and initiate the identification or verification sequence promptly when instructed to do so. The system should demonstrate iris image acquisition with a subsequent identification, verification, or rejection promptly.

3.5 Accept/Reject Lights. This test can be conducted concurrent with other tests by noting the presence or absence of the appropriate light indications concurrent with the events which they represent. A failure shall be recorded when the appropriate condition exists and the light fails to so indicate. A trial will not be considered a failure when the failure to light is as a result of system errors, or when a subsequent lamp test reveals mechanical failure of the light. These trials shall be disregarded.

3.6 Audible Signal. This test can be conducted concurrent with other tests by noting the presence or absence of an audible signal concurrent with the events which it represents. A failure shall be recorded when the appropriate condition exists and the Audible Signal fails to so indicate. A trial will not be considered a failure when the failure is as a result of system errors, or when a subsequent audio test reveals mechanical failure. These trials shall be disregarded.

3.7 Identification ≤ 5 seconds. This test can be conducted as part of the Type I False Rejection testing which uses known authentics. The average time between sequence activation and identification, shall be the criteria for satisfactory or unsatisfactory performance. Activation shall be the user starting the identification sequence by depressing

the start button on the IV unit. Identification shall be evidenced by the visual and audible indicators. A trial which results in a False Rejection shall not be considered a valid identification and shall not be considered in the computation of average time. Identification times shall be recorded, added, and divided by the number of identifications to determine the average time. Average time of greater than 5 seconds shall be unsatisfactory, and average time of 5 seconds or less shall be satisfactory.

3.8 Verification ≤ 5 seconds. This test can be conducted as part of the Type I False Rejection testing which uses known authentics. The average time between sequence activation and verification, shall be the criteria for satisfactory or unsatisfactory performance. Activation shall be the user starting the verification sequence by depressing the start button on the IV unit, after he/she has entered the appropriate PIN. Verification shall be evidenced by the visual and audible indicators. A trial which results in a False Rejection shall not be considered a valid verification and shall not be considered in the computation of average time. Verification times shall be recorded, added, and divided by the number of verifications to determine the average time. Average time of greater than 5 seconds shall be unsatisfactory, and average time of 5 seconds or less shall be satisfactory.

3.9 Enrollment ≤ 2 minutes. Enrollment time shall be the time between enrollment sequence activation by the system operator, and the audible and visual indication that the system has enrolled the individual and the sequence is complete. Note: In practical application, an astute system operator may evaluate the quality of the enrollment and elect to repeat such enrollment to improve the quality of the stored iriscode by reducing the Hamming Distance. Such subjective judgements, and independent operator actions shall not be considered in the testing program. The times for each enrollment will be summed and divided by the number of enrollments to determine the average. A failed enrollment attempt (more than 4:00 minutes) will be documented, and explained in the test report, but will not be computed as part of the average. Average enrollment time greater than 2 minutes shall be unsatisfactory. Average enrollment time of 2:00 minutes or less shall be satisfactory.

3.10 Type I errors $\leq$ 1 %. Type I error rates will be determined on the basis of a combination of identification attempts and verification attempts. Known authentics (persons known to be properly enrolled in the database, and persons known to have entered the proper PIN) will be utilized in this test. A trial will be a failure (f^a) if a known authentic is rejected three times in succession. The number of failures (F^a) will be divided by the number of trials (n) to compute an error rate (F^a/n). A computed rate greater than 1.0% will be unsatisfactory, and a computed rate of 1.0% or less will be satisfactory.

3.11 Type II errors $\leq$ 0.1%. Type II error rates will be computed by multiplying the number of un-enrolled Subject identification trials (n) times the size of the database (N) and the number of enrolled Subject identification trials (n) times the size of the database minus 1 (N - 1), since in every identification attempt the presented iris is exhaustively compared to each iriscode in the database. Each identification trial therefore results in one opportunity for a false reject, and N or N-1 opportunities for a false accept. A trial will be a failure (f^a) if any file other than that of the person presenting their iris is accepted. The number of failures (F^a) will be divided by the number of comparisons [n(N)] or [n(N-1)] to compute an error rate($F^a/\{[n(N)]+[n(N-1)]\}$. A computed rate greater than 0.1% will be unsatisfactory, and a computed rate of 0.1% or less will be satisfactory.

3.12 Four Hundred Files. The presence of at least four hundred different iriscode files will be demonstrated by querying the IriScan Brassboard System for current number of files or by dividing the number of bytes in the Master File by 512 (256 byte Iriscode and 256 bytes of administrative data).

3.13 Enroll / Recognition of Dark Eyes. The capability for enrollment and recognition of dark irises will be demonstrated as a normal part of Type I, Type II, identification, verification and enrollment testing. Evaluators and testers will observe / verify records of the eyes of a representative sample of the persons participating in the test.

3.14 40,000 File Database. The capacity of the system to enroll 40,000 irises will be evaluated by an analysis of the presence of sufficient Random Access Memory (RAM), specifically dividing the total RAM by 512. A dividend of 40,000 will constitute a successful demonstration of that capability.

3.15 Central Database Interface. This capability will be evaluated by observation of an external serial communications port and an analysis of its electronic properties.

4.0 METHODOLOGY.

4.1 Testbed. The IriScan offices, 133-Q Gaither Dr., Mt. Laurel, NJ will be the primary test bed. The testbed will be the laboratory portion of the facility wherein the system and necessary monitoring/recording equipment and devices can be positioned for optimum operation.

4.2 Test description. Tests will be conducted by knowledgeable IriScan employees in a purely laboratory environment with no attempt made to replicate or simulate operational field conditions. Each iteration (trial) will be conducted, documented, and analyzed independently. Each trial will be documented completely before proceeding on to the next. Throughput rates (system speed) will be established by averaging all individual tries without attempting to force numerous persons through the system, one after another, as rapidly as possible.

4.2.1 Identification and verification testing will be an inherent part of Type I and Type II Error testing. The results will be documented in writing as part of the documentation to establish the error rates, without formally structuring separate identification and verification test series.

4.2.2 False Acceptance testing will be conducted during and as an inherent part of Type I $\leq$ 1%, and Type II $\leq$ 0.1% Error testing, in both identification and verification mode,

with persons not enrolled in the system, and with persons enrolled in the system, but presenting incorrect PIN's during verification testing. Incorrect PIN's will be bogus (not registered in the system) as well as erroneous (using a PIN validly enrolled in the system, but not associated with the tester). The results will be documented in writing as part of the documentation to establish the error rates, without formally structuring a separate rejection test series.

4.2.3 False Rejection testing will be an inherent part of Type I and Type II Error testing. The results will be documented in writing as part of the documentation to establish the error rates, without formally structuring a separate rejection test series.

4.2.4 The user alignment demonstrations(s) will be an inherent part of Type I and Type II Error testing. The results will be documented in writing without formally structuring a separate alignment test series.

4.2.5 Accept/Reject Light testing will be an inherent part of Type I and Type II Error testing. The results will be documented in writing as part of the documentation to establish the error rates, without formally structuring a separate Accept/Reject Light test series.

4.2.6 Audible Signal testing will be an inherent part of Type I and Type II Error testing. The results will be documented in writing as part of the documentation to establish the error rates, without formally structuring a separate Audible Signal test series.

4.2.7 Identification and verification ≤ 5 seconds testing will be an inherent part of Type I and Type II Error testing. The results will be documented in writing as part of the documentation to establish the error rates, without formally structuring a separate identification and verification test series solely to measure time.

4.2.8 Enrollment ≤ 2 minutes testing will consist of enrollments of persons not previously enrolled in the system (in live, photo, and video tape modes), and enrollments of persons

who may have been previously enrolled in the system but whose files have been expunged, carefully measuring and recording the time required. Efforts will be made to make other Subjects available, and they will be used to expand the enrollment pool; however, the test will not require that each enrollment be done by a separate person, never before enrolled in the system.

4.2.9 Type I Error ≤ 1% testing will consist of two forms of testing. The first form of testing will consist of validly enrolled persons attempting to be identified or verified. Each try will consist of an individual approaching the iris reader, positioning him/herself, focusing the iris in the viewer, and activating the device. In the verification mode, the Subject will add the step of or announcing his/her PIN to the system operator for entry before approaching the reader. The second form of testing will consist of presenting pre-recorded video images of irises to the Brassboard and activating the device. An analysis of the number of tests by eye color will be made to determine the degree to which the distribution of eye color among test Subjects mirrors the number of enrollees in that eye group in the database.

4.2.10 Type II Error ≤ 0.1% testing will consist of three types of spoofing attempts (trials).

a. Non-enrolled Mode. In the identification mode, an individual's iris (or pre-recorded iris image) not enrolled in the system will be presented to the system. The results will be noted, calculating the number of trials as n (number of individual irises presented) times N (the size of the database).

b. Enrolled Mode. In the identification mode, an individual's iris (or pre-recorded iris image) enrolled in the system will be presented to the system. The results will be noted, calculating the number of trials toward Type II testing as n (number of individual irises presented) times N-1 (the size of the database less the one authentic file for the Subject).

c. Verification Mode. In the verification mode, an individual will use a bogus (non-existent) PIN, and then proceed with the verification trial. Results will be recorded. That will be followed by a trial using the valid PIN of an enrollee other than the Subject who is properly enrolled in the system. The results will be noted, calculating the number of trials as simply n, since in the verification mode, the system will only compare the presented iris with an identified file.

4.3 Test preparation. The testbed will be structured and exercised in the week before the formal testing, utilizing the proposed Data Collection Forms. Practice testing will be conducted in the week prior to the formal testing and the necessary forms and testbed configuration will be adjusted accordingly.

4.4 Test resources.

4.4.1 The Brassboard system.

4.4.2 Stopwatch.

4.4.3 Data Collection Forms.

4.4.4 Test Managers. (Two at all times that tests are conducted.)

4.4.5 Test Subjects - live. As many as possible during the four-week test, especially those who have never been enrolled in the database.

4.4.6 Test Subjects - on video. As many as 250, if possible. The video tape will be provided by Dr. Leonard Flom, IriScan Senior Scientist. The Subjects are volunteer patients from his Connecticut ophthalmology practice, and from clinics in the New York City area, including persons with diseased and/or damaged eyes. The video includes approximately 15-20 seconds of recorded images from each eye (450 - 600 images).

4.4.7 Test Subjects - still photograph. Five to ten, including photographs provided by DNA and at least two photos of persons who can come to the laboratory during the test period.

4.5 Test Scenarios.

4.5.1 Brassboard Configuration for all Trials. The system operator (Manager) will be seated at a keyboard with a CRT. The Brassboard Unit will mounted on a wall at an appropriate (recorded) height. The keyboard/CRT is connected to the Brassboard processor. The second Test Manager will observe, time and record the Trials.

4.5.2 Type II Error $\leq$ 0.1% (False Accept) Trial. This will be the initial test for every Subject who has not previously been enrolled on an IriScan system. The Subject will be positioned in front of the Brassboard Unit and the optical sensor positioned so he/she can see the eye in the feedback device. The system operator will coach movement to optimize the sharpness of the image (because this is the Subject's first contact with the system) and the Start button will be pushed (clock started). The system will search the database and activate the Reject (red) or Accept (green) light and audible signal (clock stopped). The audible signal activates twice for Reject or once for False Accept. This concludes a False Accept Trial, generating N (size of the database) comparisons. False Acceptance testing for enrolled Subjects will be conducted as an integral part of Type I (False Reject) testing, absent the coaching mentioned above.

4.5.2.1 Video Images. Un-enrolled Subjects on video tape will be utilized in False Accept Trials by direct link of the VCR to the Brassboard processor and the CRT. When a Subject's eye image appears on the CRT, the Start button will be pushed (clock started). The system searches the database and activates the Reject (red) or Accept (green) light (clock stopped). This concludes a False Accept Trial, generating N (size of database) comparisons.

4.5.2.2 Photographs. Un-enrolled Subjects on still photographs will be utilized in False Accept Trials by positioning the photo in front of the optical sensor with a stationary frame. The photo will be moved forward/backward as directed by the system operator to optimize image sharpness. The Start button will be pushed (clock started). The system searches the database and activates the appropriate light and audible signal (clock stopped). This concludes a False Accept Trial, generating N (size of database) comparisons.

4.5.2.3 After Subjects have completed False Accept Trials, they will be enrolled in the system.

4.5.3 Enrollment ≤ 2 minutes Trial. Each test Subject will receive an orientation prior to being enrolled (similar to SNL's enrollment test process). This orientation may include "practice" enrollment. The Subject will stand in front of the Brassboard Unit and position the optical sensor so he/she can see the eye in the feedback device. The Subject is instructed to look into the optical sensor with the right eye and observe the (LCD feedback) image of his/her eye. If the focus is not adequate, the Subject is instructed to move forward/backward slightly to optimize the sharpness of the image. The Subject is instructed to push the Start button to initiate image collection (clock started). The system processes the images and produces an audible sound if an acceptable series of iriscodes has been produced (clock stopped). Time T-1 (initial enrollment) is recorded and the operator collects necessary administrative data (name, SS#, organization, PIN, etc.), and enters it via data form or keyboard, as appropriate. If no acceptable series of images has been acquired in four minutes, the trial is recorded as a failed enrollment attempt. The failed Subject must be enrolled at a later time. (As soon as initial enrollment is complete, the operator switches the system to the Verify Mode, enters the enrollee's PIN, and tells the enrollee to present his eye to the optical sensor and start the system. Watching the monitor, the operator directs movement until the system acquires and processes the iris image, signified by the audible tone.) System verification that the iris data acquired matches the iriscode in the database will be signified by the green light. Time V-1 will be recorded. This concludes an Enrollment Trial.

4.5.4 Type I Error $\leq$ 1.0% (False Reject) Trials. The Subject (person enrolled in the system) stands in front of the optical sensor and moves forward/back slightly until the feedback image appears to be sharp. He/she then pushes the Start button (clock started). The system processes the images and activates the Accept light and the audible signal (clock stopped). Identification Time, T-1, is recorded. Should the red (Reject) light and audible indicator signal that the Subject was not identified, the Subject will move until a sharp feedback image is seen and again start the process. If successfully identified, Identification Time T-2 is recorded. If not, the process is initiated a third time. If a successful identification takes place, Identification Time T-3 is recorded. If not, a False Rejection is recorded. This concludes a False Reject Trial, generating one False Reject comparison and N-1 False Accept comparisons. The time required for a False Rejection is not included in the calculations for identification / verification $\leq$ 5 seconds testing.

4.5.4.1 Video Images. Enrolled Subjects on video tape will be utilized in False Reject Trials by direct link of the VCR to the Brassboard processor and the CRT. When a Subject's eye image appears on the CRT, the Start button will be pushed (clock started). The system searches the database and activates the Reject (red) or Accept (green) light (clock stopped). Retries and their timing are recorded as in the previous paragraph. This concludes a False Reject Trial, generating one False Reject comparison and N-1 False Accept comparisons.

4.5.4.2 Photographs. Enrolled Subjects on still photographs will be utilized in False Reject Trials by positioning the photo in front of the optical sensor with a stationary frame. The photo will be moved forward/backward as directed by the system operator to optimize image sharpness. The Start button will be pushed (clock started). The system searches the database and activates the appropriate light and audible signal (clock stopped). Retries and their timing are recorded as in the previous paragraph. This concludes a False Reject Trial, generating one False Reject comparison and N-1 False Accept comparisons.

Persons whose photographs have been enrolled and who are able to visit the IriScan laboratory during the test period will tested in accordance with normal False Reject procedures in paragraph 4.5.4, above.

4.6 Number of trials. For the reasons outlined below, the number of trials cannot be specified absolutely before the testing has been performed. Nor is it essential to do so. As detailed in paragraph 4.6.1, below, the confidence levels based on actual numbers will not vary greatly as the sample size varies. For example, increasing the sample size by 78% only results in a 2% increase in the accuracy of the conclusions about the whole population. It is therefore appropriate to establish a target range for trials before the test and then to express the results of the tests as a confidence level based on the actual number of trials conducted. Our target range is therefore between 280 and 500 different samples (irises). This translates to a False Reject target range of 280 trials to 500 trials, and a False accept target range of 112,000 to 200,000 comparisons.

4.6.1 Because sampling measures only a portion of the whole (infinite) population, conclusions about that whole population drawn from the sample are only estimates, and are almost universally expressed with a certain level of confidence. Thus, after sampling 280 irises, for example, one can say with 95% certainty that the results are within 9% of the value for the whole population. If one wishes to draw conclusions with greater certainty, one can say with 99% certainty that the results are within 11% of the whole population. Increasing the sampling to 500 iris comparisons improves that confidence (certainty) only slightly (95% confidence that the results are within 7% of the true population, and 99% confidence that the results are within 9% of the whole population).

4.6.2 As the testing progresses, the size of the database will vary. This has no impact on False Reject testing, where the number of comparisons is equal to the number of different irises presented (trials). It has a significant impact, however, on the number of comparisons performed for False Accept testing, since that number is the product of (n) irises presented, and (N) files in the database (un-enrolled Subject) which are all compared to the presented

iris during an exhaustive search. Additionally, when an iris which is enrolled in the database is presented, this product becomes [n(N-1)].

4.6.3 Depending upon the number of test Subjects available during the test period and the realistic amount of time available to the persons conducting the tests, the number of trials will be maximized. Because of the logistics involved, all samples will not be live presentations of irises. Although live iris presentations will be maximized, a substantial portion of presentations could be iris images obtained remotely by video tape. After such irises are presented in False Accept tests, they will be enrolled in the database to be used as part of the ongoing False Reject testing. Sufficient trials will be conducted to substantiate the test results in the form of statements of confidence level as stated in paragraph 4.6.1, above.

4.7 <u>Documentation.</u> Insofar as possible, a standard Data Collection Form will be utilized to record the results of each of the tests. Entries will consist of check marks or time (in seconds) under titled columnar headings rather than requiring a written narrative entry. Written entries will be limited to a remarks section. An example Data Collection Form follows.

				BLUE									
				BLUE-GREY									
				GREY									
				GREY-GREEN									
		FA		GREEN									
		FR	NAME	BLUE-GREEN	LIGHT								
		ENROLL	VOL 1	GREY-BROWN	STD	#	1.5 S	1.3 S	1.1 S	G	X		
	250 FILES	IDENTIFY	PHOTO 3	HAZEL	DARK	IF NEC	112 S			R	XX	G / R	
		VERIFY	REAL 3	BROWN						O	O		

IrScan Inc.

DNA BRASSBOARD SYSTEM TEST

DATA COLLECTION FORM

DATE	TRIAL NO.	SIZE DATABASE	TEST	SUBJECT	EYE COLOR	IRIS DENSITY	PIN	TIME 1	TIME 2	TIME 3	ACCEPT/ REJECT LIGHT	AUDIBLE SIGNAL	TEST MGRS	REMARKS
====	====	============	========	==============	==========	==========	======	======	======	======	=======	=======	======	======================

APPENDIX B

DEFENSE NUCLEAR AGENCY

BIOMETRIC IDENTIFICATION VERIFICATION SYSTEM

PROOF OF CONCEPT TEST REPORT

DECEMBER 1994

CONTRACT No. DNA 001-93-C-0137

IriScan Incorporated
133-Q Gaither Drive
Mt. Laurel, NJ 08054

EXECUTIVE SUMMARY

Phase II of the IriScan Incorporated contract with the Defense Nuclear Agency (DNA) included three Tasks. Task I required the development and construction of a brassboard proof-of-concept iris-based biometric identification verification system. Task II required the development of a plan for testing the brassboard proof-of-concept system, and DNA approval of that plan. Task III required performance of the brassboard proof-of-concept test in accordance with the Test Plan, collection and analysis of the test data, and development of a Test Report documenting the test results.

This Test Report describes the Proof of Concept Test and how the data was collected and includes a copy of the Test Plan and the raw data collected during the Test. Data analysis and evaluation are recounted and interpretation is discussed. Test results are detailed and Conclusions and Lessons Learned are presented.

The DNA Test of the Brassboard Proof-of-Concept Iris-based Biometric Identification Verification System started with a database of 405 IrisCodes and enrolled 160 irises:

- *The system effectively and accurately performs identification and verification* (1,944 identifications and 50 verifications in an average of 2.44 seconds each, without error, with a False Accept rate of 0);
- *The system effectively and accurately rejects impostors and persons not enrolled* (662 un-enrolled irises and 150 impostor irises were correctly rejected, while one enrolled person wearing dirty glasses was incorrectly rejected, for a False Reject rate of .05%) (rejected enrollee learned to control eyeglass reflections and was identified on second and subsequent attempts, both with and without glasses);
- *All subjects were enrolled. Average time was 25 seconds, plus typing time;*
- *The user alignment, accept/reject light and audible signal systems worked effectively and reliably, without negative comment by users;*
- *Dark eyes were handled with virtually identical speed and accuracy as others;*
- *The system made 3,100,000 file comparisons without error. There was one human image-acquisition error (resulting in the False Reject);*
- *The DNA Brassboard System met or exceeded all standards and requirements.*

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

Phase I of the IriScan Incorporated contract with the Defense Nuclear Agency (DNA) was initiated on July 19, 1993, and required the development of a Biometric Identification Verification Technology Status and Feasibility Study. The study was performed between July 1993 and January 1994. Upon completion and delivery of the study report (Phase I Final Report), DNA issued a Contract Modification exercising Option One (Phase II).

Phase II included three Tasks:

Task I required the development and fabrication of a brassboard proof-of-concept iris-based biometric identification verification system.

Task II required the development of a plan for testing the brassboard proof-of-concept system, and DNA approval of that plan. The plan included methodologies to evaluate and verify system performance in meeting the requirements identified in the contract Statement of Work.

Task III required performance of the brassboard proof-of-concept test in accordance with the Test Plan, collection and analysis of the test data, and development of a Test Report documenting the test results. Additionally, a brassboard proof-of-concept system performance demonstration was to be conducted at a time and location designated or approved by the DNA Program Manager. (This occurred November 21-22, 1994 at DNA Headquarters.)

1.2 METHODOLOGY

The Defense Nuclear Agency Brassboard Identification Verification System Test Plan was developed in generic and final stages, and approved by DNA at each stage. The Final Test Plan was delivered to DNA in mid-September, approved by DNA and published by IriScan on October 7, 1994. The methodology utilized during the test was generally as specified in the Test Plan. Minor deviations from the Test Plan are noted in the body of the report. A copy of the Test Plan is at Appendix A.

1.3 INITIAL SYSTEM STATUS

The DNA Brassboard System was fully operational for performance of enrollments, identifications and rejections in a manner similar to a fielded system. The System database was pre-loaded with 405 iris files which had been collected as of that date. (All IriScan personnel irises had been removed from the database, in order to maximize full participation during the Test.) The Mode switch used on the unit was three-position only, since the four-position switch on order did not arrive. (The four-position switch is used only on the DNA unit, since the commercial pre-production prototypes do not use a Verification Mode.) The Mode switch has Admin, Enroll, and Identify positions. Therefore, during the Test, the System was put in Admin Mode and a software "switch" set in order to exercise the Verify Mode and to do "spoof" testing. (The Brassboard System delivered to DNA is expected to have a four-position switch.)

SECTION 2

TEST PERFORMANCE

2.1 PRE-TEST

In accordance with the Test Plan, the DNA Brassboard Iris-Based Biometric Identification Proof-of-Concept System Test (hereafter called the Brassboard Test) was preceded by a Pre-Test. This Pre-Test was intended to prove that the test procedures, forms, and automated data-collection software were effective in compiling all of the data necessary to meet test requirements. The Pre-Test was initiated on October 12, 1994. It continued while necessary data collection software modifications were installed and tested and was terminated on October 19, 1994.

2.2 TEST PERIOD

The DNA Brassboard Test was initiated on Friday, October 21, 1994. From that time until the Test was terminated, enrollments, identifications, and rejections which occurred on the DNA Brassboard System were recorded, except where noted. The Test was terminated at noon on Wednesday, November 16, 1994.

2.3 TEST RESOURCES

Resources utilized during and after the Test for collecting and analyzing the data:

2.3.1 DNA Brassboard Unit (22 lbs, 18"x15"x8"), monitor, and keyboard;

2.3.2 Data Collection Forms and Enrollment Record Forms (see Appendices B and C);

2.3.3 Floppy disk drive and 3.5" floppy disks (for downloading test data from the DNA Brassboard Unit);

2.3.4 Forty-four live test subjects;

2.3.5 Seventy-three iris images on VHS video tape;

2.3.6 Two test subjects with facial images on still (command-type) photographs;

2.3.7. IriScan engineers, who entered notations in electronic files and downloaded data files, C. B. Kuhla, James T. McHugh, and James H. Lee; and

2.3.8 IriScan analysts and test managers, John E. Siedlarz, Gerald O. Williams, and Donald R. Richards.

2.4 TEST LOCATIONS

2.4.1 The DNA Brassboard System was installed in the laboratory at IriScan Headquarters, 133-Q Gaither Drive, Mt. Laurel, NJ, for all but two days of the Test Period.

2.4.2 The DNA Brassboard System was installed in a display in the American Correctional Association (New Jersey Chapter) Exhibits at the Hilton Hotel, Long Branch, NJ, October 24-25, 1994, for the purpose of expanding live-eye testing and the size of the database.

SECTION 3

TEST DATA

3.1 DATA COLLECTION

Data was collected both manually and automatically during the Brassboard System Test. Manual data was recorded on Data Collection Forms and Enrollment Record Forms by the Test Managers. Automatically collected data was placed in accessible files by the Brassboard System as it operated. These were the Rejection File, the Enrollment File and the Identification File.

3.2 DATA COLLECTION FORMS

Data Collection Forms were intended to provide a way to manually record system and test incidents which could not be identified and recorded automatically by the system. Incidents to be recorded were False Accepts, False Rejects, system failures, damage to the system, maintenance actions taken, dates and times.

There was only one incident reported during the Test, a False Reject on the second day. The Data Collection Form actually became a Test Log or record of the events which took place during the test period. The Brassboard System Test Data Collection Forms are at Appendix B.

3.3 ENROLLMENT RECORD FORMS

The Enrollment Record Forms were intended to provide a manual record of each enrollment and certain key data concerning the enrollment. Items to be recorded were the IrisCode number, the enrollee's ID number (often the last four digits of the Social Security number), the enrollee's name, which eye was enrolled (R or L), eye color (in

nine colors; blue, blue-grey, grey, grey-green, green, blue-green, grey-brown, hazel and brown), iris density (Lt, Std or Dark), seconds to enroll, date/time, and Hamming Distance of enrollment. The Hamming Distance of each enrollment is generated by the system and shown on the monitor momentarily during the enrollment. If it is not noted and recorded at that time, it is not possible to re-create it or pull it from a file. In twelve of the 160 enrollments, the Hamming distance was not recorded. Enrollment time was not recorded for iris images on video tape. The time required for a person to enroll was the time between pushing the Start button and accepting the captured image. The Test Enrollment Record Forms are at Appendix C.

3.4 REJECTIONS FILE

Each time that the Brassboard System, in the identification or verification mode, acquired an iris image, and compared it to a specific file (verification) or to the entire database without finding a match, it would show a "No Match on the monitor. The time required for this event averaged a little over one second. The system was set to require seven No Matches before giving the reject signal (red light and double-beep audible) and recording a Rejection in the automated file. In accordance with the procedure utilized by the Sandia National Laboratories in testing biometric identification / verification systems, three consecutive rejections were required before a False Reject was recorded on the Data Collection Form.

The following information was automatically recorded in the file each time there was a rejection: Eye Quality (quality of focus, basically a value that reflects the contrast ratio along the iris-limbus border); IPIX Average (computed average luminance of 128 pixels selected within the iris image); Pupil Diameter (in pixels); Iris Diameter (in pixels); and Time (in seconds, from Start button activation until Rejection signal). After the Rejects File was downloaded from the Brassboard System, several data items were added: Average Time computation; Number of IrisCodes in the database when the reject took place; Number of Comparisons which could have produced a False Accept (number of

IrisCodes x 7); and Cumulative Number of Comparisons (which could have produced a False Accept).

A total of 812 valid rejections and one false rejection were recorded during the Test period. The Rejects File is at Appendix D.

3.5 ENROLLMENTS FILE

Each time that an iris was enrolled in the Brassboard System during the Test period, the system automatically recorded the following data: File Number (IrisCode number); Enrollee's Name; Eye Enrolled (R or L); Enrollee's ID Number; and the Date / Time of the Enrollment. Since the ID numbers were not relevant for test purposes, they were not included in the final printout of the Enrollments File. N/A was placed in this column. The system time was not always accurately set, and since time of day was not critical to calculations, the system time of the first enrollment of the day is shown for many enrollments that day. Finally, iris images presented on video tape are not identified by name, but by Volunteer Number. The Enrollments File is at Appendix E.

3.6 IDENTIFICATIONS FILE

In the identification or verification mode, each time that the Brassboard System acquired an iris image, compared it to a specific file (verification) or to the entire database and found a match, an identification was automatically recorded. The following information is recorded for each identification: File Number (IrisCode) of the matching file; Hamming Distance of the match; Number of Bits Compared (between the code of the iris presented and the IrisCode in the database); Number of Bits Which Disagree (between the two IrisCodes); Rotation of the Iris Presented (clock-wise or counter-clock-wise, in degrees); and Time (in seconds between activation of the Start button and activation of the identification signals).

After the Identifications File was downloaded from the Brassboard System, several data items were added: Average Time computation; Number of IrisCodes in the database when the identification took place; N-1 (the number of comparisons which could have produced a False Accept); and Cumulative Number of Comparisons (which could have produced a False Accept).

A total of 1,994 Identifications / Verifications were recorded during the Test period. The Identifications File is at Appendix F.

3.7 DATA COLLECTION PROCEDURES

The potential enrollee would receive a brief orientation on the DNA Brassboard System, its components, capabilities and how it operates. A demonstration identification would also take place so the enrollee would know generally what actions to take. The enrollee would then be coached into position for the system to acquire a good iris image and the system started. (See paragraph 4.2.3, below.) Since enrollment had not taken place, the resulting "No Matches" and Rejections demonstrated that the system would not generate a False Accept. If there was time, the enrollee was asked to generate five Rejections with each eye. Next the enrollment took place. Generally, both eyes were enrolled. Finally, the system was put in Identification Mode and the enrollee was asked to identify five times with each eye.

Since the correct four-position Mode switch did not arrive in time to be installed before the Test, only Admin (download, mark files, modify software, etc.), Enroll and Identify Modes were readily available during the test. When time was available, the system would be placed in Admin Mode and a software switch made to enable Verification. Then, ID numbers would be entered via the keyboard and multiple Verifications and spoof attempts (utilizing other ID numbers and generating Rejections) would take place with all the new enrollees and other persons available.

Data was downloaded to floppy disks from the Brassboard System's hard drive at the end of a testing period (the total test was broken into eight periods of roughly equal activity rather than daily or weekly). The data was contained in three files, Identifications, Rejections and Enrollments. Those files were then imported into a Lotus spreadsheet file and additional columns added to calculate statistics germane to the test.

SECTION 4

DATA ANALYSIS AND INTERPRETATION

4.1 ANALYSIS

Upon completion of the Data Collection Phase of the DNA Brassboard Proof-of-Concept System Test (October 21 - November 16), the data was analyzed using two methodologies.

4.1.1 QUICK SUMMARIZATION ANALYSIS

Since the Brassboard System Demonstration was scheduled for November 21-22, all of the data was quickly reviewed and analyzed with the intention of developing a summary of key test items which could be verbally presented to the DNA Program Manager at the Demonstration. The key items were: number of identifications (1,994); number of valid rejections (812); number of False Rejects (1); number of False Accepts (0); and total number of file comparisons (approximately 3,100,000).

4.1.2 DETAILED ANALYSIS

Upon completion of the DNA Demonstration, all of the collected data was subjected to a detailed analysis and evaluation as this Test Report was being developed and particularly as the Test Results (Section 5) prepared. This included an item by item assessment of each data element of the Forms and Files contained in the Appendices. As occurs in all system performance tests of this kind, some significantly abnormal data points were identified. These significantly abnormal data points were subjected to special analysis, evaluation, and tracking of the circumstances surrounding their generation, and were handled as discussed below. All of the other data were used in development of the Test Results.

4.2 INTERPRETATION

The results of the Brassboard Test in Section 5 below should be interpreted and considered in light of the following issues, comments, and caveats.

4.2.1 The early portion of the test (days 4 and 5 specifically) was conducted in conjunction with an exhibit at the New Jersey Chapter of the American Correctional Association, in Longbranch NJ. We believed that moving the unit from the laboratory environment (a deviation from the Test Plan) was a reasonable measure in light of the opportunity to gather data which we might not otherwise obtain. We concluded that having the unit at a large gathering was an opportunity to obtain a larger number of irises than we would have been able to obtain by bringing individuals to the IriScan offices in ones and twos. Secondly, "new" irises (those never before entered in the system) gave us an opportunity to observe and document the behavior and adaptability of subjects who had never previously encountered an iris identification device. Finally, we felt that the subjects we would encounter at a public exhibition would be inclined to demonstrate characteristics more "real world" than in a laboratory environment constrained by formal indoctrination.

4.2.2 An analysis of identifications after the exhibition mentioned above, revealed some extremely long, and unrealistic, identification times. We realized that two common practices were responsible for this. It is important to remember that the event timer is started when the "Start" button is depressed and will continue to run (accumulate time) until either an identification or rejection decision is made. The system does not terminate the search sequence after a predetermined time. First, to demonstrate the system to interested persons, we, the system operators, would initiate the identification sequence and show the subjects how the additional aiming device (the triangle of light in the iris image) could be used to assist focus. To make this clear, operators would move into the focal field very slowly, and in fact, would sometimes turn from the device to point out (on the monitor screen) certain aspects of the iris image or the aiming clues.

Turning back to the Brassboard unit and eventually obtaining an identification resulted in some identification sequences of 60, 90, 120 seconds and longer. On more than one occasion, subjects left the exhibit area without enrolling and we failed to terminate the identification sequence for periods of up to nearly 5 minutes. As a result, four identification times in excess of 60 seconds, which could be positively linked to similar scenarios were eliminated from the data analysis.

4.2.3 An additional tendency contributed to excessive identification times. When subjects approached the Brassboard unit and began to make their initial attempts to acquire their iris image in the system, no illumination was available. (To preserve illuminator life, a software adjustment had been made to extinguish the illuminator after each identification. Pressing the Start button turns the illuminator on again.) Instinctively, to aid subjects in initial familiarization with the iris acquisition, the IriScan staff would press the start button to provide illumination, and all of those first-try identification times thus included familiarization time as well. Once the unit was returned to the laboratory, the procedures were rewritten such that initial familiarization was always conducted in the enroll mode wherein the illuminator remained on all the time. Only after a subject was oriented and could readily reacquire his iris image was the unit placed in the identification mode and an identification/rejection trial conducted.

4.2.4 Finally, the research and experimentation mind-set influenced our test data in the early stages of the Brassboard testing. As an example, it was automatic, when discussing such things as area of the search pattern, to approach the nearest unit (more often than not the DNA Brassboard unit) to experiment with proper placement of the eye in the field of view. As a result, some identification sequences were initiated and followed by placement of the iris image in the extreme margins of the field of view to test the image search pattern. These too extended many of the identification sequences until the problem was identified by the IriScan staff. Overall, the test average identification time of 2.44 seconds was well within the required 5 second criteria. In practical application, the time will probably average more on the order of 1.5 to 1.7 seconds.

4.2.5 The occurrence of only one error (Type I, False Reject) during the Brassboard Test makes broad and sweeping generalizations about confidence levels or error rates unsuitable. Certainly, insufficient errors were experienced during the Brassboard Test to define an operational Crossover Error Rate (CER). However it is reasonable to assume that it parallels the theoretical CER established in the initial iris identification research and development. That is, .005% (1/20,000) based on samples with 173 degrees of freedom and a database of 500.

SECTION 5

TEST RESULTS

5.1 IDENTIFICATION

The DNA Test demonstrated that the Brassboard Proof-of-Concept System performs accurate identification of persons enrolled in the system. This conclusion is supported by the fact that nearly 2,000 identifications were made without error.

5.2 VERIFICATION

The DNA Test demonstrated that the Brassboard System is capable of performing accurate identity verification. This conclusion is supported by the fact that approximately 50 verifications were made without error. However, it should be noted that the high speed and accuracy of the Brassboard System's identification mode call into question the utility of a verification capability. Since verification actually takes longer than identification, and the accuracy rate is essentially the same, it may be simpler to avoid the cost of extra equipment (card reader or keypad), and potential human error inherent in the verification process. (Commercial model IriScan entry control systems will only identify.)

5.3 REJECTION

The DNA Test demonstrated that the Brassboard System performs accurate rejection of impostors and persons not enrolled in the system. This conclusion is supported by the fact that 812 valid rejections were recorded when 662 attempts with irises not enrolled in the system and 150 impostor attempts (spoofing) were rejected. One False Rejection was recorded and documented. This subject enrolled without glasses and was correctly identified without glasses. However, the first time he attempted identification while wearing bifocal glasses (which had not been cleaned in some time) he was falsely

rejected. This rejection occurred because he was initially unable to position himself so the reflections on his lenses appeared to be outside his irises. Immediately, on his second attempt, he was correctly identified. And, with clean lenses, he had no further rejection problems on several subsequent attempts.

The shortest rejection time was 7.0 seconds and the longest was 124.3 seconds. This longest time was a result of the same phenomenon discussed in paragraph 4.2.2 above. The mean rejection time was 10.26 seconds and the Standard Deviation (SD) was 5.95 seconds. There were four times over one minute which we considered anomalies. However, because we could not associate them with any specific scenario, as with the identifications (see paragraph 5.7, below), we included them in the above calculations. If they had been excluded, the longest time would have been 36.3 seconds, the mean 9.91, and the SD 2.7 seconds.

5.4 USER ALIGNMENT

The DNA Test of the Brassboard System demonstrated that the user alignment / feedback system was effective and acceptable to the people who had to utilize the hardware. Though a few people had minor initial difficulty during their orientation in "locating their eye" in the image feedback window, all were able to do it readily by the time they had enrolled both eyes. None stated a concern over future ability to use the alignment / feedback system.

5.5 ACCEPT / REJECT LIGHTS

The DNA Test of the Brassboard System demonstrated that the Accept / Reject Lights were effective in signaling identification or rejection and performed reliably. The system uses Light Emitting Diodes (LED) as the means for signaling status. The green LED was activated for an identification/verification and the red LED for a rejection. These LED's remain on for five seconds before going out. If the Start button is pushed during

the five second period, the green/red LED goes out and the yellow LED comes on, indicating that the system is processing. The yellow LED goes out when the green/red LED comes on. The LED's worked on every trial and the users were able to immediately determine identification or rejection without referring to the demonstration monitor.

5.6 AUDIBLE SIGNAL

The DNA Test of the Brassboard System demonstrated that the Audible Signal was effective in signaling identification, verification or rejection and was reliable in performance. The signal "beeped" once for identification or verification and twice on a rejection. The audible signal worked on every trial without failure and the users were able to immediately determine identification, verification or rejection without referring to the demonstration monitor.

5.7 IDENTIFICATION ≤ 5 SECONDS

The DNA Test of the Brassboard System demonstrated that identification takes place in less than five seconds on average. This conclusion is supported by the Identifications File (Appendix F) which shows that the time for 1,944 identifications (and aapproximately 50 verifications) averaged 2.44 seconds. The minimum time was 1.0 seconds and the maximum 37.5 seconds, with a Standard Deviation of 2.63 seconds. The data still include five points in the 20-37.5 second range which we are certain are also cases where the identification sequence was interrupted before an iris image was acquired. However, since we could not document these incidents these data were left in the file.

5.8 VERIFICATION ≤ 5 SECONDS

The Brassboard Test indicated that the image-acquisition / "system" time for verification is less than five seconds. A verification is the same as an identification except that the

presented iris is compared to only the pre-designated file, instead of the entire database. The verification of identity simply appears as another data point in the Identifications File and it is therefore impossible to separate and analyze these trials for comparison to identifications. It is known, however, that there were no cases of interrupted sequence during verification trials. There was no data to indicate that the average time of the approximately 50 verification trials deviated significantly from the 2.44 second average of the 1,944 identification trials. As with identification, the most time consuming functions during verification are image acquisition, analysis and digitization. The comparison time for two files is less than comparing one file against 500. The overall time for verification, however, is greater than that of identification because of the need to enter a Personal Identification Number (PIN).

5.9 ENROLLMENT ≤ 2 MINUTES

5.9.1 Enrollment process. The enrollment process consists of a fixed, "system" component and several variable, enrollee- or operator-influenced components. When an operator feels that the enrollee is in proper position and the eye is in focus and centered, he activates the Start button. In 0.1 second, the system grabs 3 frames (iris images). The system processes the three images, developing an IrisCode for each image in about one second. If the geometric mean of the Hamming Distance (HD) in three pair-wise comparisons of the IrisCodes is less than .32, the system presents a screen display to the operator. In an optimal and acceptable enrollment, the process described thus far takes a total of about 1.1 seconds. In an unacceptable enrollment (where the mean Hamming Distance is greater than .32), the system briefly flashes the screen display, and immediately repeats the process until it detects an acceptable HD. This process is indeterminate in the sense that the system will repeat indefinitely until an acceptable HD is detected. Once an acceptable HD is obtained, the operator is presented with a prompt which asks "Desire to store this IrisCode and enroll a textfile?" Through experience, we have determined that the quality of identifications after enrollment is a function of, or at least partially dependent upon, the quality of the enrollment

image. Therefore, by policy, HDs greater than .15 were generally rejected by the operator, and the process was repeated by again pushing the Start button. This accounts for some of the variance in enrollment times (from 9 to 60 seconds). Once an operator elects to enroll the image, he responds "Yes" with a keystroke, and is presented with an opportunity to enter the subject's name, which eye was presented, and a 4-digit ID number which he solicits from the subject. This manual process adds another indeterminate amount of time, which we considered administrative data-entry time, not included in the computation of Enrollment ≤ 2 minutes. The system then provides the operator with an opportunity to review the data which has been entered. The prompt is, "Is this correct? (Y, N, or A (abort))". The operator strikes the "Y" key and then "enter." Instantly, the prompt appears, "Temporary database updated. Update permanent database? [Y-N] (Def Y)". When the operator strikes "Y" or "enter", the system begins a five-second process of updating the permanent database, and then automatically begins the enrollment cycle over again with the prompt, "Press Start button". Thus the "system" time for enrollment (that is, the minimum amount of time required by the system to complete all of its functions when directed) is about 6.1 seconds. The total enrollment time is indeterminant because of the variables of a) time required for the enrollee to move into sharp focus, b) operator assessment of the quality of image, and c) the operator's expertise at typing. To further speed the process and reduce data-entry time to a minimum, the system will query after the first enrollment, "Desire to enroll the other eye?" and if the answer is yes, will automatically provide all the previous information upon capture of a suitable image during the second iris enrollment.

5.9.2 Enrollment speed. Thirty-Seven enrollments were clocked from the time the Start button was pushed until the operator accepted an enrollment image. This included automatic "system-generated" retries and retries based on an operator's dissatisfaction with the mean Hamming Distance (HD). The shortest time was 9 seconds, and the longest time was 60 seconds, with an average enrollment time of 18.9 seconds. Enrollment time consists of image-acquisition time (which averaged 18.9 seconds in this Test), a fixed, system-dependent component of about 6.1 seconds, and a variable, operator-

influenced data-entry component. In this Test, with an average of only 25 seconds required for two of the three necessary components, the total time will be less than two minutes, no matter how Enrollment Time is calculated.

5.10 TYPE I ERRORS ≤ 1%

5.10.1 EXPERIENCED FALSE REJECT RATE

During the test, there were 1,994 successful identifications/verifications. Records were kept to document the one case of a False Reject which met the definition in the test plan (three consecutive Rejects of the same iris). [That False Accept was the result of a subject's continued identification attempts with dirty glasses. Immediately after the False Reject, the subject successfully angled his head in a manner which moved the "blooming" caused by reflected light to an area outside the iris image. By practicing this technique, the subject successfully identified (with glasses) numerous times during the remainder of the test.] With a single False Reject in 1,994 trials, the <u>experienced</u> False Reject rate was 0.05% (1 / 1995).

5.10.2 THEORETICAL FALSE REJECT RATE

The theoretical False Reject Rate at a Hamming Distance criterion setting of .28 as was used in this test is 1 in 9,000, or 0.01%.

5.11 TYPE II ERRORS ≤ .1%

5.11.1 FALSE ACCEPT TESTING

False Accept testing was conducted in two primary ways and one secondary way.

a. Primary. Generally, before enrollment, subjects attempted to be identified five times with each eye. Each rejection was the result of seven separate iris images being compared exhaustively to the entire database. As a result, each rejection sequence provided between 2, 848 and 3,955 comparisons or opportunities for a False Accept (database size times 7, or a minimum of 405 X 7 for the first test to 565 X 7 for the last test).

b. Primary. During the verification demonstrations, erroneous PINs were entered for enrolled subjects ("spoof" tests, if you will) to attempt identifications against another enrollee's file. (Bogus PINs, that is, PINs not assigned to an IrisCode, were automatically rejected by the system.) Each attempt to spoof the system resulted in only 7 opportunities for a false accept because there was no exhaustive database search performed.

c. Secondary. During False Reject testing in the identification mode, each identification attempt generated one opportunity for a False Reject, but N (database size) minus 1 (N-1) opportunities for a False Accept. This is a legitimate, but not widely used practice. In previous biometric testing, so few technologies operated in the identification (exhaustive search) mode that such calculations were mentioned only in an offhanded way. As a result, it provides a serendipitous expansion of the number of file comparisons useable in error rate calculations. We followed the practice of using the word "trial" to describe one person attempting identification.

5.11.2 FALSE ACCEPT TRIALS AND COMPARISONS

There were a total of 815 primary False Accept trials (identifications and spoofs), resulting in 2,170,143 comparisons which could have resulted in a False Accept. Additionally, there were 1994 False Reject trials resulting in 929,518 secondary False

Accept comparisons. Thus, for purposes of computing error rates, there were a total of 3,099,661 False Accept comparisons.

5.11.3 EXPERIENCED FALSE ACCEPT RATE

There were zero False Accepts experienced during the testing and thus the FA rate was 0 (0 / 3,099,661 = 0).

5.11.4 THEORETICAL FALSE ACCEPT RATE

The theoretical False Accept Rate at a Hamming Distance criterion setting of .28 as was used in this test is 1 in 120,000, or .0008%.

5.12 FOUR HUNDRED FILES

5.12.1 DATABASE SIZE At the start of testing, the database consisted of 405 IrisCode files. During the course of the test, 160 IrisCodes were added (87 live irises and 73 videotaped irises) to bring the total database size to 565. Twenty-Seven of the 565 IrisCodes were repeats (duplicates), resulting in a database of 538 unique irises.

> (NOTE: It is likely that in fact, there were 565 different IrisCodes representing 538 unique irises. This is true for two reasons. 1) It is highly unlikely that any two enrollments of the same iris result in identical codes because of the variability of the process of presenting an iris. The number of disagreeing bits and the number of bits compared varies with such things as focus, ambient lighting, head angle, and rotation. Each enrollment also involves taking three images, computing a geometric mean, and choosing the IrisCode closest to that mean. Two separate presentations (for a total of six different IrisCodes) undoubtedly resulted in selecting two separate IrisCodes for enrollment which were slightly, but identifiably different. 2) except for the three operator errors mentioned below, all

of the duplicates (repeats) were cases where the initial enrollment had previously been accomplished on Bench Model 2.5, with a 7-bit frame grabber providing a range of 128 possible gray scale values per pixel, and the second or repeat enrollment was accomplished on the DNA Brassboard unit with an 8-bit frame grabber and a range of 256 possible gray scale values per pixel.

5.12.2 DATABASE CHARACTER

5.12.2.1 IrisCode size. All of the 405 IrisCodes present in the database at the start of testing were from IriScan's Bench Model 2.5 (an early, laboratory device) which used only 7 bits of the 8-bit frame grabber and could thus capture only 128 gray scale values per pixel. All 160 IrisCodes added during the test were enrolled using the DNA Brassboard unit with 8-bit frame grabber, capturing and digitizing 256 gray scale values.

5.12.2.2 Duplicates. As mentioned, 27 of the 565 IrisCodes were repeats (duplicates). This occurred, for two reasons. In three cases, operator error resulted in duplicate enrollment of one of a live subject's eyes during the course of the DNA testing. In 24 cases (16 videotaped images, and 8 images from live subjects), irises previously enrolled on the 7-bit frame grabber were re-enrolled on the 8-bit system. This was done to see which IrisCodes were likely to be matched in subsequent identifications. In only one case out of about 50 such identifications did the system identify on the 7-bit IrisCode.

5.12.2.3 Computations. Because of the minute number of duplicate comparisons made relative to the total (less than .0016%) during the test, no effort was made to adjust the formula from N-1 to N-2 during those trials.

5.13 ENROLLMENT/RECOGNITION OF DARK EYES

After eliminating all duplicate irises from the tally, an analysis was made of the distribution of darkness (density) of the irises in the database. The analysis was made using the

same nine categories of iris color used when analyzing the distribution for the Phase I Final Report. As can be seen from Table 5-1, Database Distribution By Color, the greatest concentration of iris colors were in the lightest and the darkest groups. The numerical majority of irises in the database were dark, with 58% in the two darkest categories, and 35% in the two lightest categories.

During the test, there were 849 identifications of dark irises and 1,145 identifications of light irises, averaging 2.59 seconds and 2.33 seconds respectively.

Like identifications, differences in the enrollment acquisition times of the dark versus light irises were not significantly different, averaging 18.6 seconds and 18.8 seconds respectively.

TABLE 5-1

DATABASE DISTRIBUTION BY COLOR

Color	Orig. D/B	New	Total	Duplicates	Adj. Total	Percentage
Blue	133	38	171	(7)	164	30%
Blue/grey	20	6	26	(1)	25	5%
Grey	24	2	26	(1)	25	5%
Blue/green	5	2	7	(0)	7	1%
Grey/green	6	0	6	(0)	6	1%
Grey/brown	0	0	0	(0)	0	0
Green	0	0	0	(0)	0	0
Hazel	33	30	63	(13)	50	9%
Brown	184	82	266	(5)	261	49%
TOTAL	405	160	565	(27)	538	100%

5.14 40,000 FILE DATABASE

The DNA Brassboard Proof-of-Concept System has been operated successfully in the current hardware configuration by electronically duplicating the 400 IrisCode database ten times. This increased system identification time by 0.6 seconds over a 400 IrisCode database. The DNA Brassboard Unit was configured with two, 210 Megabyte hard drives which, if used exclusively for IrisCode storage, would have accommodated 820,312 IrisCodes. In reality, one hard drive was configured as backup for the primary, and approximately 400 Kilobytes of the primary was used for record keeping. Thus, 409,375 IrisCodes could have been stored in the unit's test configuration.

5.15 CENTRAL DATABASE INTERFACE

The DNA Brassboard Proof-of-Concept System hardware has two serial ports and is capable of providing a communication means to a central database. Data transfer can be accomplished between the Brassboard Unit and any other computer or peripheral device (such as a hard drive, or floppy drive), through a serial port.

SECTION 6

CONCLUSIONS AND LESSONS LEARNED

The DNA Brassboard unit met or exceeded all standards and Operational Performance Requirements specified in the Test Plan and contract Statement Of Work.

Aside from the technical parameters which have been previously discussed, the unit performed well in those areas of primary concern to DNA and potential users:

The unit easily enrolled and identified / verified dark irises. Nearly 60% of the IrisCodes in the database were in the two darkest categories of eyes.

Although control of ambient lighting is still a matter of some importance in operational applications, the unit experienced no difficulty in operating in any of the lighting environments encountered during the test.

User acceptance was excellent. The 20-watt quartz-halogen light, operated at approximately 7 watts and filtered with a magenta acrylic filter provided a comfortable amount of light without harshness or irritation. Users were able to see clearly and simply the image of the eye they should expect to see when they approached the unit. The additional focusing method (the triangular reflection of light low in the iris image) provided an immediate feedback mechanism to even presbyopic individuals. Most initial orientations required less than 30 seconds to train subjects on how to acquire a proper image.

The unit enrolled every iris presented to it.

The unit was absolutely accurate in the area of False Accepts, allowing no errors in over 3 million opportunities. It was 99.95% accurate in the area of False

Rejects, with only 1 out of 1,995 opportunities. The reason for that error was identified, corrected and never repeated.

The existing protection against counterfeiting (currently available only in the Enrollment Mode), should be explored further. It seems likely that it (or some variant) would also be effective in the identification / verification mode.

Contact lenses posed no problem in either enrollment or identification / verification. Enrollment without contacts can be followed by identification / verification with the lenses, and vice versa, without impacting accuracy or speed. Similarly, the system handles imprecisely positioned lenses (not in same exact position on the eye every time) and colored contacts without difficulty.

We learned that dirty and scratched glasses cause blooming that can interfere with identification / verification if not consciously and effectively avoided by subjects. We identified techniques which can be applied by virtually anyone to easily move blooming to an area that will not affect the I/V process. However, it is important to note that the dynamic range of the system acquisition and processing capabilities should not be expected to compensate for conditions (e.g., scratched / dirty glasses) that are beyond the engineering design and ignore common sense judgement. The system should not be expected to compensate for uncooperative individuals or glasses that should be replaced.

An ancillary lesson from the foregoing is that False Rejects can be made to happen in many ways and that an operational False Reject Rate may well be a function of factors beyond the control of any biometric manufacturer. The degree to which subjects <u>want</u> to make the system operate can well influence Type I errors. The attentiveness of subjects, their concentration, and their preoccupation with other things in the environment and/or their lives may well induce higher Type I error rates than the system is capable of. In short, a poorly presented biometric feature, which exceeds the system design parameters has a high probability of being rejected.

ANNEX 1

APPENDIX A

TEST PLAN

for

DEFENSE NUCLEAR AGENCY

BRASSBOARD IDENTIFICATION / VERIFICATION SYSTEM

(Withdrawn)

ANNEX 2
APPENDIX B

IriScan Inc
DNA BRASSBOARD TEST
DATA-COLLECTION FORM

DATE	EXACT TIME	FALSE ACCEPT	FALSE REJECT	INCIDENT SYSTEM FAIL	DAMAGE	MAINT ACTION	REMARKS - DETAILS - COMMENTS	REPORTED BY	TEL NO.
10/21/94	1401						Initial False Accept tests. 5 times R, 5 times L	GOW GOW	
	1405						Enroll	GOW GOW	
	1415						Initial False Reject tests. 5 times R, 5 times L. Identification	GOW GOW	
	1529						False Reject tests. 5 times R, 5 times L. Verification	GOW GOW	
10/22/94	1048						Ran in ID mode for 2-5 min w/o timeout. ID'd to break cycle.	GOW GOW	
	1100 - 1200						Enrolled & tested Russ, Julie, & Kate Thurston. D. & J. Richards	GOW GOW	
	1300		X				User acquisition & dirty/scratched glasses. No good image. (DRR)	GOW GOW	
10/23/94- 10/25/94							Testing at NJ chapter of ACA in Longbranch NJ.	GOW GOW	
10/27/94	0800						Initial enrollment from video tape.	GOW GOW	
	0900 - 1140						Testing with Lt. Col. Gore present	GOW GOW	
	1147- 1210						Multiple verifications & spoofing tsts	GOW GOW	
10/28/94	1229						Verification testing	5 R, 5 L	GOW
								5 R, 5 L	DDR
							Spoof testing (various PIN's: CBK, J. Gore, J. Lee)	5 R, 5 L	DDR
								5 R, 5 L	GOW
							Verification testing	5 R, 5 L	CBK
							Spoof testing (GOW PIN)	5 R, 5 L	CBK
							Verification testing	5 R, 5 L	J. Lee
							Spoof testing (J. Gore PIN)	5 R, 5 L	J. Lee
							Verification testing	5 R, 5 L	RMS
							Spoof testing (J. Gore PIN)	5 R, 5 L	RMS
							Identifications		CBK
11/01/94	1145						PAULA SIEDLARZ, FA TESTING	5 R, 5 L	
							ENROLL		
							PAULA SIEDLARZ, FR TESTING	5 R, 5 L	
							LORNA, FA TESTING	5 R, 5 L	
							ENROLL		
							LORNA, FR TESTING	5 R, 5 L	
XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXX
XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXX
XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXX
XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXX

IriScan Inc
DNA BRASSBOARD TEST
DATA-COLLECTION FORM

DATE	EXACT TIME	FALSE ACCEPT	FALSE REJECT	INCIDENT SYSTEM FAIL	DAMAGE	MAINT ACTION	REMARKS - DETAILS - COMMENTS	REPORTED BY	TEL NO.
11/02/94	920						FA testing, T. Whittle, enroll		
							FR testing. No L iriscode present. Reinrolled T. Whittle		
							FA testing, J. McHugh, enrolled		
							FR testing, J. McHugh		
							FA testing JES, enrolled		
							FR testing, JES		
	1430						FA testing, J. Nelson, enrolled		
							FR testing, J. Nelson		
11/03/94	1130						FA testing, Costello enrolled		
							FR testing, 5R, 5L Costello		
							Video FR/FA testing		
11/12/94	1250						J. Williams, G. Wells identified on previous file #'s 308,309 and 310,311 respectively		
							but are listed in master record 1 # higher. Reinrolled		
11/14/94							Corrected master file numbering. H. Fineberg had 1, not 2 eyes enrolled.		
11/15/94	1108						Ran FA tests on 70 video irises.		
11/16/94	1334						Started enrollment of video irises.		
	1703						Completed enrollment of video irises (52)		
11/16/94	0732						Started FR testing on video irises.		
							Discovered & corrected logging error. Ran FR tests on video irises.		
							Ran FA tests on previously unenrollable irises.		
XXXXXXXX	0900	XXXXXXXX	XXXXXXXX	XXXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXX END TESTING XXXXXXXXX	XXXXXXXXXXXXXXX	
XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXX LAST ENTRY XXXXXXXXX	XXXXXXXXXXXXXXX	

ANNEX 3

14-Dec-94

APPENDIX C

IriScan Inc
DNA BRASBOARD TEST
ENROLLMENT RECORD

COLOR - Blue, Blue-Grey, Grey, Grey-Green Green, Blue-Green, Grey-Brown, Hazel, Brown
DENSITY -- Light - Std - Dark

SHEET ___#1________

IRISCODE NO.	ID NO.	ENROLLEE NAME	EYE	EYE COLOR	IRIS DENSITY	SECONDS ENROLL TIME	DATE/ TIME	HD	REMARKS
406	3322	WILLIAMS, G.	R	BLUE	STD		10/21/94 1415	.02	
407	3322	WILLIAMS, G.	L	BLUE	STD		10/21/94 1416	.02	
408	3676	THURSTON, R.	R	BLUE	LT		10/22/94 1114	.036	
409	3676	THURSTON, R.	L	BLUE	LT		1116		
410	7973	THURSTON, J.	R	BLUE	DRK		1125	.08	
411	7973	THURSTON, J.	L	BLUE	DRK		1127	.03	
412	8793	RICHARDS, J.	R	BLUE	STD		1130	.06	
413	8793	RICHARDS, J.	L	BLUE	STD		1132	.03	
414	1111	THURSTON, K.	R	BLUE	STD		1142		ACTIVE 4-YR OLD TIRED AFTER 1ST ENROLLMENT
415	9948	RICHARDS, D.	R	BLUE	LT	51 SEC	1145		
416	9948	RICHARDS, D.	L	BLUE	LT	51 SEC	1147	.09	
417	3876	LEE, J.	R	HAZ	DRK		10/23/94 1702	.05	
418	3876	LEE, J.	L	HAZ	DRK		1702	08	
419	8066	GREGORIO, J.	R	BL/GRY	STD		10/24/94 0845	.05	
420	8066	GREGORIO, J.	R	BL/GRY	STD		0847	.05	
421	4055	ANSELL, S.	R	BROWN	LT		0930	.08	SUBJECT LEFT BEFORE COMPLETING L EYE
422	5073	MACKINNON	R	BROWN	STD	16 SEC	0945	.06	
423	5073	MACKINNON	L	BROWN	STD	16 SEC	0945	.06	
424	1406	KRAUSZ, G.	R	BROWN	STD		1030		
425	1406	KRAUSZ, G.	L	BROWN	STD		1030		
426	5819	BROWN, K.	R	BROWN	STD		1040	.04	
427	5819	BROWN, K.	L	BROWN	STD		1041	.04	
428	7717	GREGORIO, P.	R	BROWN	STD		1100	.15	
429	7717	GREGORIO, P.	L	BROWN	STD	14 SEC	1102	.21	
430	2314	SASALA	R	HAZEL	STD		1110	.08	
431	2314	SASALA	L	HAZEL	STD		1111	.08	
432	8746	FITZ MAURICE, D.	R	BL/GRY	STD		1125	.06	
433	8746	FITZ MAURICE, D.	L	BL/GRY	STD	12 SEC	1126	.05	
434	7184	RYAN, PHIL	R	BLUE	LIGHT		1700	.15	EXHIBIT CLOSED BEFORE COMPLETING L EYE
XXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXX	X	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXX	X	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

IriScan Inc
DNA BRASBOARD TEST
ENROLLMENT RECORD

COLOR - Blue, Blue-Grey, Grey, Grey-Green, Green, Blue-Green, Grey-Brown, Hazel, Brown
DENSITY -- Light - Std - Dark

SHEET ____#2______

IRISCODE NO.	ID NO.	ENROLLEE NAME	EYE	EYE COLOR	IRIS DENSITY	SECONDS ENROLL TIME	DATE/ TIME	HD	REMARKS
======	=====	==================		=====	=====	=====	=====	=====	=========================
435	6402	COFFEY, J.	R	HAZEL	LT		10/25/94 0830	.11	
436	6402	COFFEY, J.	L	HAZEL	LT		0832	.016	
437	2277	ARETINO	R	BLUE	DRK		0910	.08	
438	2277	ARETINO	L	BLUE	DRK		0912	.09	
439	7766	GRAY, D.	R	BROWN	DRK		0940	.17	
440	7766	GRAY, D.	L	BROWN	DRK		0942	.17	
441	0264	HOWARD, R.	R	HAZEL	DRK		1500	0.07	
442	0264	HOWARD, R.	R	HAZEL	DRK		1501	0.06	
443	0264	HOWARD, R.	L	HAZEL	DRK		1505	0.06	
444	5421	VOLUNTEER #14	L	BROWN	DRK		10/27/94 0830	.09	FROM VIDEO TAPE R EYE IMAGE UNSUITABLE
445	5422	VOLUNTEER #28	R	BROWN	DRK		1030	.08	FROM VIDEO TAPE
446	5422	VOLUNTEER #28	L	BROWN	DRK		1032	.08	FROM VIDEO TAPE
447	0031	KUHLA, B.	R	BLUE	STD		1045	.03	
448	0031	KUHLA, B.	L	BLUE	STD		1044	.03	
449	1045	GORE, J.	R	BROWN	DRK		1050	.07	
450	1045	GORE, J.	L	BROWN	DRK		1052	.06	DROPPED OFF SCREEN WITHOUT ENROLLING. RE-ENROLLED
451	3248	SNYDER, J.	L	BROWN	DRK	60 SEC	1115	.08	SUBJECT PUT LEFT EYE IN BY MISTAKE
452	3248	SNYDER J.	L	BROWN	DRK		1117	.16	WOULDN'T IDENTIFY. THOUGHT ENROLLMENT FAILED. RE-ENROLLED.
453	3248	SNYDER J.	R	BROWN	DRK		1115	.08	SUBJECT PUT RIGHT EYE IN BY MISTAKE (MISLABELED AS "L" IN RECOG.REC)
454	1516	QUINN, R.	R	BROWN	DRK		1458	0.06	
455	1516	QUINN, R.	L	BROWN	DRK		1459	0.08	
456	1211	PROTOS, A.	R	BROWN	DRK		10/31/94 1235	0.16	4-YR OLD
457	1211	PROTOS, A.	I	BROWN	DRK		1240	0.21	4-YR OLD
458	5423	VOL #1	R	HAZEL	DRK		1328	0.08	FROM VIDEO TAPE
459	5423	VOL #1	L	HAZEL	DRK		1331	0.17	FROM VIDEO TAPE
460	5423	VOL #2	* R	HAZEL	LT			0.06	* OPERATOR MISLABELED AS "L" FROM VIDEO TAPE
461	5423	VOL #2	L	HAZEL	LT			0.05	FROM VIDEO TAPE
462	5424	VOL #4	R	BLUE	STD			0.14	FROM VIDEO TAPE
463	5425	VOL #4	L	BLUE	STD		1421	0.07	FROM VIDEO TAPE
XXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXX	X	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXX	X	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

IriScan Inc
DNA BRASBOARD TEST
ENROLLMENT RECORD

COLOR - Blue, Blue-Grey, Grey, Grey-Green Green, Blue-Green, Grey-Brown, Hazel, Brown
DENSITY -- Light - Std - Dark

SHEET #3

IRISCODE NO.	ID NO.	ENROLLEE NAME	EYE	EYE COLOR	IRIS DENSITY	SECONDS ENROLL TIME	DATE/ TIME	HD	REMARKS
464	5426	VOL #8	R	BLUE	LT		10/31/94 1432	0.08	FROM VIDEO TAPE
465	5426	VOL #8	L	BLUE	LT			0.08	FROM VIDEO TAPE
466	5427	VOL #3	R	BLUE	STD		1439	0.035	FROM VIDEO TAPE
467	5427	VOL #3	L	BLUE	STD			0.06	FROM VIDEO TAPE
468	5428	VOL #15	R	BLUE	STD			0.04	FROM VIDEO TAPE
469	5428	VOL #15	L	BLUE	STD			0.03	6 TRIES FROM VIDEO TAPE
470	5429	VOL #16	L	BROWN	STD			0.1	R TOO BLURRY TO ENROLL FROM VIDEO TAPE
471	5429	VOL #17	R	BROWN	STD			0.1	FROM VIDEO TAPE
472	5430	VOL #17	L	BROWN	STD			0.06	FROM VIDEO TAPE
473	7198	SIEDLARZ, P.	R	HAZEL	DRK	12	11/01/94 1152	0.08	
474	7198	SIEDLARZ, P.	L	HAZEL	DRK	12	1153	0.04	
475	2514	LORNA	R	HAZEL	STD	13	1155	0.05	
476	2514	LORNA	L	HAZEL	STD	18	1156	0.08	
477	5431	VOL #29	R	HAZEL	LT	14	11/02/94 0925		FROM VIDEO TAPE
478	5431	VOL #29	L	HAZEL	LT	27	0828		FROM VIDEO TAPE
479	5431	VOL #29	L	HAZEL	LT	13	0830		FROM VIDEO TAPE
480	0057	WHITTLE, T.	R	HAZEL	LT	14	0935	0.05	
481	0057	WHITTLE, T.	L	HAZEL	LT	27	0938	0.04	FILE NOT PRESENT WHEN IDENTIFYING. REENROLLED BELOW
482	0057	WHITTLE, T.	L	HAZEL	LT	27	0938	0.05	REENROLLMENT
483	1552	MCHUGH, J.	R	BROWN	DRK	12	0950	0.07	
484	1552	MCHUGH, J.	L	BROWN	DRK	- 17	0951	0.03	
485	9916	SIEDLARZ, J.	R	BU/GRN	STD	15		0.09	
486	9916	SIEDLARZ, J.	L	BU/GRN	STD	11		0.04	
487	8924	NELSON, J.	R	BLUE	STD			0.07	
488	5457	DONOHUE, J.	R	BLUE	STD				
489	5457	DONOHUE, J.	L	BLUE	STD				
490	7223	FINEBURG, H.	R	GREY	STD				
491	7223	FINEBURG, H.	L	GREY	STD				
492	6336	COSTELLO, R.	R	BLUE	STD	9	11/03/94 1125	0.09	
493	6336	COSTELLO, R.	L	BLUE	STD	9	1126	0.03	

IriScan Inc
DNA BRASBOARD TEST
ENROLLMENT RECORD

COLOR - Blue, Blue-Grey, Grey, Grey-Green
Green, Blue-Green, Grey-Brown, Hazel, Brown
DENSITY -- Light - Std - Dark

SHEET ____#4_______

IRISCODE NO.	ID NO.	ENROLLEE NAME	EYE	EYE COLOR	IRIS DENSITY	SECONDS ENROLL TIME	DATE/ TIME	HD	REMARKS
======	=====	===================		=====	=====	=====	=====	=====	=========================
494	1715	OVADENKO, D.	L	BLUE	STD	18	11/03/94 1245	0.07	
495	1715	OVADENKO, D.	R	BLUE	STD	14	1248	0.04	
496	3321	CHAPEK, J.	R	BROWN	STD	14	11/08/94 1730	0.12	
497	3321	CHAPEK, J.	L	BROWN	STD	15	1730	0.07	
498	6064	AHRENS, J.	R	HAZ	STD	18	1735	0.04	
499	6064	AHRENS, J.	L	HAZ	STD	18	1735	0.07	
500	3138	PETERS, J.	R	BLUE	STD	14	11/09/94 1230	0.07	
501	3138	PETERS, J.	L	BLUE	STD	14	1230	0.04	
502	3959	NICKELL, D.	R	BLUE	DARK	17	1240	0.12	
503	3959	NICKELL, D.	L	BLUE	DARK	15	1240	0.04	
504	2583	GENGLER, A.	R	BL/GRY	LIGHT		11/10/94 0915	0.01	
505	2583	GENGLER, A.	L	BL/GRY	LIGHT		0915	0.029	
506		WEYERS, K.	R	BLUE	LIGHT	15	11/11/94 1630	0.07	
507		WEYERS, K.	L	BLUE	LIGHT	17		0.04	
508	1307	WILLIAMS, J.	R	HAZEL	STD		11/12/94 1250	0.06	CHECK #'S OF OLD FILES.
509	1307	WILLIAMS, J.	L	HAZEL	STD			0.12	
510	1588	WELLS, G.	R	HAZEL	STD			0.07	
511	1588	WELLS, G.	L	HAZEL	STD			0.04	
512	2149	CALDWELL, J.	R	BROWN	STD	18		0.03	
513	2149	CALDWELL, J.	L	BROWN	STD	16		0.06	
514	5432	VOL #58	R	Brown	STD		11/15/94 1334	0.14	ENROLLED FROM VIDEO
515	5432	VOL #58	L	brown	STD			0.05	ENROLLED FROM VIDEO
516	5433	VOL #59	R	BLUE	LIGHT			0.07	ENROLLED FROM VIDEO
517	5433	VOL #59	L	Blue	light			0.12	ENROLLED FROM VIDEO
518	5434	VOL #60	L	BROWN	STD			0.19	ENROLLED FROM VIDEO
519	5435	VOL #61	R	BROWN	DARK			0.11	ENROLLED FROM VIDEO
520	5435	VOL #61	L	BROWN	DARK			0.16	ENROLLED FROM VIDEO
521	5436	VOL #62	R	BROWN	DARK			0.09	ENROLLED FROM VIDEO
522	5436	VOL #62	L	BROWN	DARK			0.12	ENROLLED FROM VIDEO
XXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXX	X	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXX	X	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

IriScan Inc
DNA BRASBOARD TEST
ENROLLMENT RECORD

COLOR - Blue, Blue-Grey, Grey, Grey-Green
Green, Blue-Green, Grey-Brown, Hazel, Brown
DENSITY -- Light - Std - Dark

SHEET ____#5_______

IRISCODE NO.	ID NO.	ENROLLEE NAME	EYE	EYE COLOR	IRIS DENSITY	SECONDS ENROLL TIME	DATE/ TIME	HD	REMARKS
======	=====	===================		=====	=====	=====	=====	=====	==========================
523	3437	VOL #63	R	BROWN	DARK			0.09	ENROLLED FROM VIDEO
524	3439	VOL #65	R	BROWN	DARK			0.12	ENROLLED FROM VIDEO
525	3439	VOL #65	L	BROWN	DARK			0.16	ENROLLED FROM VIDEO
526	3440	VOL #66	L	BROWN	DARK			0.11	ENROLLED FROM VIDEO
527	3441	VOL #67	R	BROWN	DARK			0.14	ENROLLED FROM VIDEO
528	3441	VOL #67	L	BROWN	DARK			0.16	ENROLLED FROM VIDEO
529	3442	VOL #68	R	BROWN	DARK			0.15	ENROLLED FROM VIDEO
530	3443	VOL #70	R	BROWN	DARK			0.07	ENROLLED FROM VIDEO
531	3443	VOL #70	L	BROWN	DARK			0.08	ENROLLED FROM VIDEO
532	3444	VOL #72	R	BROWN	DARK			0.1	ENROLLED FROM VIDEO
533	3444	VOL #72	L	BROWN	DARK			0.12	ENROLLED FROM VIDEO
534	3445	VOL #73	R	BROWN	DARK			0.09	ENROLLED FROM VIDEO
535	3445	VOL #73	L	BROWN	DARK			0.08	ENROLLED FROM VIDEO
536	3446	VOL #74	R	BROWN	DARK			0.13	ENROLLED FROM VIDEO
537	3447	VOL #75	R	BROWN	DARK			0.107	ENROLLED FROM VIDEO
538	3447	VOL #75	L	BROWN	DARK			0.157	ENROLLED FROM VIDEO
539	3448	VOL #76	R	BROWN	DARK			0.05	ENROLLED FROM VIDEO
540	3448	VOL #76	L	BROWN	DARK			0.16	ENROLLED FROM VIDEO
541	3449	VOL #77	R	BROWN	DARK			0.156	ENROLLED FROM VIDEO
542	3449	VOL #77	L	BROWN	DARK			0.182	ENROLLED FROM VIDEO
543	3450	VOL #78	R	BROWN	DARK			0.156	ENROLLED FROM VIDEO
544	3451	VOL #80	R	BROWN	DARK			0.09	ENROLLED FROM VIDEO
545	3451	VOL #80	L	BROWN	DARK			0.16	ENROLLED FROM VIDEO
546	3452	VOL #81	R	BROWN	DARK			0.11	ENROLLED FROM VIDEO
547	3453	VOL #81	L	BROWN	DARK			0.09	ENROLLED FROM VIDEO
548	3453	VOL #82	R	BROWN	DARK			0.06	ENROLLED FROM VIDEO
549	3453	VOL #82	L	BROWN	DARK			0.179	ENROLLED FROM VIDEO
550	3454	VOL #83	R	BROWN	DARK			0.088	ENROLLED FROM VIDEO
551	3454	VOL #83	L	BROWN	DARK			0.096	ENROLLED FROM VIDEO
xxxxxxxxxx	xxxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	x	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxx	xxxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	x	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

IriScan Inc
DNA BRASBOARD TEST
ENROLLMENT RECORD

COLOR - Blue, Blue-Grey, Grey, Grey-Green
Green, Blue-Green, Grey-Brown, Hazel, Brown
DENSITY -- Light - Std - Dark

SHEET ____#6______

IRISCODE NO.	ID NO.	ENROLLEE NAME	EYE	EYE COLOR	IRIS DENSITY	SECONDS ENROLL TIME	DATE/ TIME	HD	REMARKS
552	3455	VOL #85	R	BROWN	DARK		11/15/94 1627	0.078	ENROLLED FROM VIDEO
553	3455	VOL #85	L	BROWN	DARK			0.155	ENROLLED FROM VIDEO
554	3456	VOL #86	R	BROWN	DARK			0.185	ENROLLED FROM VIDEO
555	3456	VOL #86	L	BROWN	DARK			0.16	ENROLLED FROM VIDEO
556	3457	VOL #87	R	BROWN	DARK			0.07	ENROLLED FROM VIDEO
557	3457	VOL #87	L	BROWN	DARK			0.08	ENROLLED FROM VIDEO
558	3458	VOL #88	R	BROWN	DARK			0.11	ENROLLED FROM VIDEO
559	3458	VOL #88	L	BROWN	DARK			0.096	ENROLLED FROM VIDEO
560	3459	VOL #89	R	BROWN	DARK			0.065	ENROLLED FROM VIDEO
561	3459	VOL #89	L	BROWN	DARK			0.05	ENROLLED FROM VIDEO
562	3460	VOL #90	R	BROWN	DARK			0.097	ENROLLED FROM VIDEO
563	3460	VOL #90	L	BROWN	DARK			0.108	ENROLLED FROM VIDEO
564	3461	VOL #92	R	BROWN	DARK			0.066	ENROLLED FROM VIDEO
565	3461	VOL #92	L	BROWN	DARK		1703	0.04	ENROLLED FROM VIDEO

ANNEX 4

APPENDIX D

REJECTS FILE

19-DEC-94

OCTOBER 21...NOVEMBER 16, 1994

TRIAL #	EYE QUAL	IPIX AVG	PUPIL DIAM	IRIS DIAM	TIME	AVG TIME	NO. OF FILES	# OF COMP	CUM COMP
1	1.493	81	72	252	9.3	9.30	407	2849	2,849
2	1.482	80	80	250	9.3	9.30	407	2849	5,698
3	1.489	79	84	250	9.3	9.30	407	2849	8,547
4	1.493	80	86	256	9.4	9.33	407	2849	11,396
5	1.503	80	76	254	9.3	9.32	407	2849	14,245
6	1.497	79	94	262	9.3	9.32	407	2849	17,094
7	1.524	78	102	260	9.4	9.33	407	2849	19,943
8	1.493	79	86	252	9.3	9.33	407	2849	22,792
9	1.509	78	90	260	9.4	9.33	407	2849	25,641
10	1.516	77	96	260	9.4	9.34	407	2849	28,490
11	1.360	95	90	244	12.5	9.63	409	2863	31,353
12	1.442	90	94	254	11.5	9.78	409	2863	34,216
13	1.498	90	88	248	11.3	9.90	409	2863	37,079
14	1.179	107	22	168	11.1	9.99	409	2863	39,942
15	1.532	70	24	188	9.2	9.93	409	2863	42,805
16	1.556	94	104	270	9.1	9.88	409	2863	45,668
17	1.768	68	56	188	9.0	9.83	409	2863	48,531
18	1.611	95	78	268	9.0	9.78	409	2863	51,394
19	1.511	96	108	276	9.0	9.74	409	2863	54,257
20	1.629	94	88	262	9.4	9.73	409	2863	57,120
21	1.670	93	82	264	9.2	9.70	411	2877	59,997
22	1.702	91	80	264	9.4	9.69	411	2877	62,874
23	1.687	91	84	264	9.8	9.69	411	2877	65,751
24	1.658	92	92	266	9.3	9.68	411	2877	68,628
25	1.588	85	108	262	21.6	10.15	411	2877	71,505
26	1.628	86	108	260	9.3	10.12	411	2877	74,382
27	1.612	87	114	260	9.4	10.09	411	2877	77,259
28	1.650	88	112	262	9.4	10.07	411	2877	80,136
29	1.581	88	106	258	9.5	10.05	411	2877	83,013
30	1.743	71	54	186	9.1	10.02	411	2877	85,890
31	1.753	69	56	186	9.2	9.99	413	2891	88,781
32	1.474	90	114	262	9.3	9.97	413	2891	91,672
33	1.611	89	116	256	9.2	9.95	413	2891	94,563
34	1.445	88	112	260	19.1	10.21	413	2891	97,454
35	1.456	87	116	256	9.2	10.19	413	2891	100,345
36	1.499	81	114	260	9.2	10.16	413	2891	103,236
37	1.455	85	120	262	9.2	10.13	413	2891	106,127
38	1.480	83	122	264	8.9	10.10	413	2891	109,018
39	1.471	84	122	266	9.0	10.07	413	2891	111,909
40	1.471	69	46	206	9.1	10.05	413	2891	114,800
41	1.451	84	110	284	9.9	10.04	413	2891	117,691
42	1.445	73	40	212	9.1	10.02	413	2891	120,582
43	1.618	70	68	202	9.2	10.00	413	2891	123,473
44	1.536	78	44	210	9.0	9.98	415	2905	126,378
45	1.387	85	116	272	9.2	9.96	415	2905	129,283
46	2.183	45	28	194	124.3	12.45	415	2905	132,188
47	1.485	89	102	262	10.8	12.41	415	2905	135,093
48	1.462	89	108	264	9.4	12.35	415	2905	137,998
49	1.483	89	106	266	9.4	12.29	415	2905	140,903
50	1.470	87	110	264	9.4	12.23	415	2905	143,808
51	1.462	87	114	266	9.4	12.18	415	2905	146,713
52	1.408	96	108	268	16.8	12.27	415	2905	149,618
53	1.422	95	114	264	9.2	12.21	415	2905	152,523
54	1.657	70	44	190	9.1	12.15	417	2919	155,442
55	1.521	69	52	194	9.1	12.09	417	2919	158,361
56	1.716	67	42	190	9.1	12.04	417	2919	161,280
57	1.355	91	44	180	9.9	12.00	417	2919	164,199
58	1.251	89	38	168	9.7	11.96	417	2919	167,118

59	1.262	97	104	250	24.1	12.17	417	2919	170,037
60	1.345	82	28	162	9.8	12.13	417	2919	172,956
61	1.575	67	54	200	10.4	12.10	417	2919	175,875
62	1.594	82	108	270	13.4	12.12	417	2919	178,794
63	1.665	81	106	256	9.3	12.08	417	2919	181,713
64	1.614	86	106	262	9.6	12.04	417	2919	184,632
65	1.577	86	108	264	9.2	12.00	419	2933	187,565
66	1.590	86	108	262	9.1	11.95	419	2933	190,498
67	1.597	87	108	262	9.0	11.91	419	2933	193,431
68	1.581	91	108	268	21.2	12.04	419	2933	196,364
69	1.587	90	108	266	9.3	12.00	419	2933	199,297
70	1.681	65	52	188	9.4	11.97	419	2933	202,230
71	1.606	86	108	264	9.3	11.93	419	2933	205,163
72	1.548	88	106	268	9.4	11.89	419	2933	208,096
73	1.339	87	28	160	15.2	11.94	419	2933	211,029
74	1.431	79	72	262	10.6	11.92	419	2933	213,962
75	1.422	85	68	272	16.5	11.98	419	2933	216,895
76	1.522	71	28	168	9.3	11.95	419	2933	219,828
77	1.603	72	94	248	9.4	11.91	419	2933	222,761
78	1.446	74	26	184	23.5	12.06	419	2933	225,694
79	1.152	99	84	266	13.8	12.08	419	2933	228,627
80	1.176	100	102	282	9.1	12.05	419	2933	231,560
81	1.464	91	114	278	10.0	12.02	419	2933	234,493
82	1.455	92	122	276	9.6	11.99	419	2933	237,426
83	1.603	74	28	180	13.4	12.01	419	2933	240,359
84	1.476	78	108	268	9.3	11.98	419	2933	243,292
85	1.992	51	30	206	9.2	11.94	419	2933	246,225
86	1.717	56	58	202	15.1	11.98	419	2933	249,158
87	1.186	85	22	172	18.4	12.06	419	2933	252,091
88	1.519	78	114	264	9.3	12.02	419	2933	255,024
89	1.804	54	50	200	9.1	11.99	419	2933	257,957
90	1.345	72	38	228	20.1	12.08	419	2933	260,890
91	1.407	81	80	270	9.6	12.05	421	2947	263,837
92	1.401	88	84	284	12.1	12.05	421	2947	266,784
93	1.352	93	22	160	10.1	12.03	421	2947	269,731
94	1.178	92	42	232	17.5	12.09	423	2961	272,692
95	1.444	96	102	286	14.9	12.12	423	2961	275,653
96	1.399	87	74	266	9.3	12.09	423	2961	278,614
97	1.439	69	48	288	9.4	12.06	425	2975	281,589
98	1.446	70	50	286	9.4	12.04	425	2975	284,564
99	1.477	77	28	216	14.9	12.07	425	2975	287,539
100	1.381	87	26	170	9.1	12.04	427	2989	290,528
101	1.378	106	62	286	11.4	12.03	427	2989	293,517
102	1.460	99	66	264	9.4	12.00	427	2989	296,506
103	1.504	74	50	170	14.8	12.03	429	3003	299,509
104	1.514	77	56	172	21.8	12.13	429	3003	302,512
105	1.470	101	86	300	17.5	12.18	429	3003	305,515
106	1.476	91	60	274	21.9	12.27	433	3031	308,546
107	1.491	64	36	164	11.0	12.26	433	3031	311,577
108	1.504	64	32	170	9.1	12.23	433	3031	314,608
109	1.423	66	32	162	9.7	12.20	435	3045	317,653
110	1.504	68	40	168	9.0	12.17	435	3045	320,698
111	1.336	93	62	286	9.5	12.15	435	3045	323,743
112	1.407	75	60	184	9.1	12.12	437	3059	326,802
113	1.377	64	24	172	9.2	12.10	437	3059	329,861
114	1.456	86	68	262	9.2	12.07	437	3059	332,920
115	1.467	86	72	266	9.2	12.05	439	3073	335,993
116	1.600	82	80	272	9.4	12.02	439	3073	339,066
117	1.576	82	82	272	9.3	12.00	439	3073	342,139
118	1.568	81	80	272	9.3	11.98	443	3101	345,240
119	1.590	82	80	270	9.3	11.96	443	3101	348,341
120	1.612	82	80	268	9.2	11.93	443	3101	351,442
121	1.551	82	78	274	9.3	11.91	443	3101	354,543
122	1.608	82	78	272	12.1	11.91	443	3101	357,644
123	1.653	79	76	270	9.5	11.89	443	3101	360,745
124	1.667	79	74	268	9.2	11.87	443	3101	363,846
125	1.683	79	72	266	9.3	11.85	443	3101	366,947
126	1.650	80	62	272	9.3	11.83	443	3101	370,048

127	1.667	80	64	272	9.4	11.81	443	3101	373,149
128	1.659	80	64	270	9.2	11.79	443	3101	376,250
129	1.651	79	64	268	9.3	11.77	443	3101	379,351
130	1.661	80	62	270	9.3	11.75	443	3101	382,452
131	1.875	68	52	202	19.5	11.81	443	3101	385,553
132	1.324	106	124	272	9.1	11.79	443	3101	388,654
133	1.694	73	62	188	9.0	11.77	443	3101	391,755
134	1.836	72	58	192	9.0	11.75	443	3101	394,856
135	1.290	99	122	276	9.2	11.73	443	3101	397,957
136	1.182	95	88	280	11.1	11.73	443	3101	401,058
137	1.759	76	40	172	10.2	11.71	443	3101	404,159
138	1.417	86	42	198	8.9	11.69	443	3101	407,260
139	1.169	97	82	250	9.2	11.68	443	3101	410,361
140	1.537	75	32	148	9.1	11.66	443	3101	413,462
141	1.324	90	86	208	9.7	11.64	443	3101	416,563
142	1.680	73	34	148	9.7	11.63	443	3101	419,664
143	1.842	79	50	172	9.0	11.61	443	3101	422,765
144	1.840	78	46	172	9.0	11.59	443	3101	425,866
145	2.100	63	50	176	10.4	11.59	444	3108	428,974
146	1.374	73	46	148	9.0	11.57	444	3108	432,082
147	1.466	74	48	186	9.8	11.56	444	3108	435,190
148	1.459	76	44	186	9.1	11.54	444	3108	438,298
149	1.375	79	28	162	9.1	11.52	444	3108	441,406
150	1.514	73	42	128	10.1	11.51	444	3108	444,514
151	1.195	92	28	180	10.4	11.51	444	3108	447,622
152	1.188	87	98	194	10.8	11.50	444	3108	450,730
153	1.390	76	34	176	25.8	11.59	444	3108	453,838
154	1.487	64	36	180	9.8	11.58	444	3108	456,946
155	1.449	60	30	180	9.1	11.57	444	3108	460,054
156	1.356	67	34	184	9.1	11.55	444	3108	463,162
157	1.215	86	22	166	88.4	12.04	446	3122	466,284
158	1.277	79	88	214	13.0	12.05	446	3122	469,406
159	1.171	98	104	254	9.1	12.03	446	3122	472,528
160	1.793	57	56	194	8.7	12.01	446	3122	475,650
161	1.274	101	114	264	9.0	11.99	446	3122	478,772
162	1.806	66	52	188	8.8	11.97	446	3122	481,894
163	1.674	68	60	202	8.8	11.95	446	3122	485,016
164	1.673	70	62	202	9.1	11.93	446	3122	488,138
165	1.766	61	72	208	9.3	11.92	446	3122	491,260
166	2.080	59	62	202	8.9	11.90	446	3122	494,382
167	1.740	84	66	222	8.9	11.88	446	3122	497,504
168	1.714	89	62	220	9.0	11.86	446	3122	500,626
169	1.878	82	72	216	8.8	11.84	446	3122	503,748
170	1.667	66	86	194	9.2	11.83	446	3122	506,870
171	1.583	81	78	268	12.6	11.83	446	3122	509,992
172	1.609	81	78	264	9.8	11.82	446	3122	513,114
173	1.641	82	72	266	9.3	11.81	446	3122	516,236
174	1.433	82	84	270	9.3	11.79	446	3122	519,358
175	1.622	82	78	268	9.6	11.78	446	3122	522,480
176	1.629	81	72	272	9.4	11.77	446	3122	525,602
177	1.637	80	74	268	9.3	11.75	448	3136	528,738
178	1.623	81	80	272	9.4	11.74	448	3136	531,874
179	1.643	80	80	268	9.3	11.73	448	3136	535,010
180	1.646	80	78	266	9.3	11.71	448	3136	538,146
181	1.506	102	72	272	9.8	11.70	448	3136	541,282
182	1.631	72	22	170	9.7	11.69	448	3136	544,418
183	1.471	104	78	278	9.7	11.68	448	3136	547,554
184	1.522	67	22	172	9.3	11.67	448	3136	550,690
185	1.486	105	74	272	9.6	11.66	448	3136	553,826
186	1.510	102	74	272	13.0	11.66	448	3136	556,962
187	1.482	107	72	276	10.2	11.66	450	3150	560,112
188	1.748	71	56	170	9.1	11.64	450	3150	563,262
189	1.506	76	24	170	9.7	11.63	450	3150	566,412
190	1.438	109	78	284	9.6	11.62	450	3150	569,562
191	1.572	76	22	172	9.7	11.61	450	3150	572,712
192	1.492	104	72	268	10.2	11.60	450	3150	575,862
193	1.789	68	26	168	9.4	11.59	450	3150	579,012
194	1.459	109	76	276	9.6	11.58	450	3150	582,162

195	1.469	105	74	272	9.6	11.57	450	3150	585,312
196	1.605	72	54	268	56.0	11.80	450	3150	588,462
197	1.348	106	80	268	11.0	11.79	450	3150	591,612
198	1.362	105	84	264	12.7	11.80	450	3150	594,762
199	1.317	104	78	256	14.8	11.81	450	3150	597,912
200	1.290	105	76	260	20.2	11.86	450	3150	601,062
201	1.282	106	78	256	14.1	11.87	450	3150	604,212
202	1.523	75	22	170	13.3	11.87	450	3150	607,362
203	1.255	108	86	270	13.0	11.88	450	3150	610,512
204	1.252	106	86	270	15.7	11.90	450	3150	613,662
205	1.219	99	74	228	15.0	11.91	453	3171	616,833
206	1.527	79	26	182	17.5	11.94	453	3171	620,004
207	1.277	108	90	266	9.5	11.93	453	3171	623,175
208	1.261	102	82	260	10.9	11.92	453	3171	626,346
209	1.244	104	86	264	9.5	11.91	453	3171	629,517
210	1.239	108	52	160	51.0	12.10	453	3171	632,688
211	1.619	75	92	266	7.5	12.08	453	3171	635,859
212	1.572	76	94	266	7.6	12.06	453	3171	639,030
213	1.455	105	72	278	10.2	12.05	453	3171	642,201
214	1.483	103	72	282	7.8	12.03	453	3171	645,372
215	1.566	85	90	266	7.6	12.01	453	3171	648,543
216	1.453	94	100	268	7.5	11.99	453	3171	651,714
217	1.626	64	46	238	15.7	12.00	453	3171	654,885
218	1.581	82	76	268	9.7	11.99	453	3171	658,056
219	1.556	81	78	270	7.5	11.97	453	3171	661,227
220	1.607	76	56	172	9.5	11.96	455	3185	664,412
221	1.409	74	36	176	10.5	11.95	455	3185	667,597
222	1.450	68	32	194	16.5	11.97	455	3185	670,782
223	1.565	82	108	256	23.2	12.02	455	3185	673,967
224	1.593	64	38	186	9.4	12.01	455	3185	677,152
225	1.332	65	62	182	9.3	12.00	455	3185	680,337
226	1.462	72	24	190	11.5	12.00	455	3185	683,522
227	1.555	71	36	176	9.3	11.99	455	3185	686,707
228	1.606	69	46	186	9.3	11.98	455	3185	689,892
229	1.427	80	44	188	9.2	11.96	455	3185	693,077
230	1.578	70	42	184	9.3	11.95	455	3185	696,262
231	1.476	85	26	172	9.3	11.94	455	3185	699,447
232	1.536	83	92	268	7.5	11.92	455	3185	702,632
233	1.524	80	92	264	7.5	11.90	455	3185	705,817
234	1.469	86	102	278	7.6	11.88	455	3185	709,002
235	1.435	86	92	264	7.4	11.86	455	3185	712,187
236	1.439	85	96	276	7.4	11.85	455	3185	715,372
237	1.237	105	98	264	7.3	11.83	455	3185	718,557
238	1.548	83	26	184	7.5	11.81	455	3185	721,742
239	1.321	99	98	264	7.4	11.79	455	3185	724,927
240	1.357	103	94	262	7.4	11.77	455	3185	728,112
241	1.580	77	96	276	7.7	11.75	455	3185	731,297
242	1.553	75	98	272	7.5	11.74	455	3185	734,482
243	1.545	74	94	266	7.6	11.72	455	3185	737,667
244	1.532	74	96	266	7.6	11.70	455	3185	740,852
245	1.554	75	92	266	7.5	11.69	455	3185	744,037
246	1.568	77	104	276	7.7	11.67	455	3185	747,222
247	1.565	77	108	276	8.4	11.66	455	3185	750,407
248	1.569	77	108	276	7.8	11.64	455	3185	753,592
249	1.569	79	104	278	7.9	11.63	455	3185	756,777
250	1.499	76	94	280	7.8	11.61	455	3185	759,962
251	1.620	81	72	264	7.6	11.59	455	3185	763,147
252	1.605	82	70	264	7.6	11.58	455	3185	766,332
253	1.593	82	72	266	7.6	11.56	455	3185	769,517
254	1.608	81	72	264	7.5	11.55	455	3185	772,702
255	1.577	82	64	264	7.5	11.53	455	3185	775,887
256	1.609	81	62	276	7.6	11.52	455	3185	779,072
257	1.617	81	58	268	7.5	11.50	455	3185	782,257
258	1.626	81	58	268	7.5	11.48	455	3185	785,442
259	1.588	81	56	268	7.5	11.47	455	3185	788,627
260	1.575	82	56	276	7.5	11.45	455	3185	791,812
261	1.423	57	44	162	24.8	11.50	455	3185	794,997
262	1.441	92	100	264	7.8	11.49	455	3185	798,182

263	1.575	89	94	260	7.7	11.48	455	3185	801,367
264	1.535	89	94	256	7.5	11.46	455	3185	804,552
265	1.361	66	28	190	7.4	11.45	455	3185	807,737
266	1.471	93	80	252	11.7	11.45	455	3185	810,922
267	1.408	96	88	262	7.7	11.43	455	3185	814,107
268	1.417	90	88	252	7.5	11.42	455	3185	817,292
269	1.579	90	94	260	8.4	11.41	455	3185	820,477
270	1.538	91	86	264	7.7	11.39	455	3185	823,662
271	1.380	98	82	262	7.7	11.38	455	3185	826,847
272	1.344	94	80	262	7.7	11.37	455	3185	830,032
273	1.364	96	78	262	8.9	11.36	455	3185	833,217
274	1.532	70	26	182	7.6	11.34	455	3185	836,402
275	1.322	109	74	266	7.8	11.33	455	3185	839,587
276	1.267	111	76	268	7.7	11.32	455	3185	842,772
277	1.332	105	80	262	9.1	11.31	455	3185	845,957
278	1.292	111	80	276	7.8	11.30	455	3185	849,142
279	1.264	110	72	266	7.7	11.28	455	3185	852,327
280	1.774	52	46	170	8.8	11.28	455	3185	855,512
281	1.919	46	44	188	8.3	11.26	455	3185	858,697
282	1.543	76	22	170	9.8	11.26	455	3185	861,882
283	1.655	73	124	280	8.1	11.25	455	3185	865,067
284	1.579	78	42	182	9.2	11.24	455	3185	868,252
285	1.318	77	34	254	9.1	11.23	455	3185	871,437
286	1.224	92	48	272	11.5	11.23	455	3185	874,622
287	1.439	87	42	200	9.0	11.23	455	3185	877,807
288	1.180	106	68	210	10.4	11.22	455	3185	880,992
289	1.183	105	62	190	10.4	11.22	455	3185	884,177
290	1.204	101	60	186	9.6	11.22	455	3185	887,362
291	1.528	76	28	150	9.6	11.21	455	3185	890,547
292	1.696	70	34	148	9.6	11.20	455	3185	893,732
293	1.865	77	48	172	9.1	11.20	455	3185	896,917
294	1.869	76	38	172	9.0	11.19	455	3185	900,102
295	2.094	62	54	176	9.7	11.18	455	3185	903,287
296	2.149	62	44	178	9.7	11.18	455	3185	906,472
297	1.421	76	42	186	9.0	11.17	455	3185	909,657
298	1.491	75	38	184	9.0	11.16	455	3185	912,842
299	1.817	77	50	178	9.2	11.16	472	3304	916,146
300	1.942	75	48	176	9.2	11.15	472	3304	919,450
301	1.160	88	34	216	11.1	11.15	472	3304	922,754
302	1.456	63	36	178	8.9	11.14	472	3304	926,058
303	1.235	68	34	170	9.7	11.14	472	3304	929,362
304	1.276	85	102	268	18.2	11.16	472	3304	932,666
305	1.216	90	76	162	13.3	11.17	472	3304	935,970
306	1.273	87	86	288	12.8	11.17	472	3304	939,274
307	1.338	79	74	198	9.1	11.17	472	3304	942,578
308	1.826	61	54	188	9.1	11.16	472	3304	945,882
309	1.764	64	48	188	9.6	11.16	472	3304	949,186
310	1.840	60	54	190	9.0	11.15	472	3304	952,490
311	1.632	66	50	182	11.3	11.15	472	3304	955,794
312	1.845	61	52	192	8.8	11.14	472	3304	959,098
313	1.824	61	54	188	8.8	11.13	472	3304	962,402
314	1.824	61	58	192	8.8	11.13	472	3304	965,706
315	1.737	58	26	144	9.0	11.12	472	3304	969,010
316	1.160	77	52	156	10.6	11.12	472	3304	972,314
317	1.538	74	42	182	9.7	11.11	472	3304	975,618
318	1.538	76	42	182	9.1	11.11	472	3304	978,922
319	1.310	96	80	246	9.4	11.10	472	3304	982,226
320	1.318	96	80	244	9.2	11.10	472	3304	985,530
321	1.318	96	80	244	9.2	11.09	472	3304	988,834
322	1.228	112	76	234	9.5	11.09	472	3304	992,138
323	1.218	113	76	236	9.3	11.08	472	3304	995,442
324	1.423	69	36	230	9.3	11.08	472	3304	998,746
325	1.607	82	68	272	9.4	11.07	472	3304	1,002,050
326	1.599	82	70	276	9.4	11.06	472	3304	1,005,354
327	1.593	58	26	168	9.9	11.06	472	3304	1,008,658
328	1.620	83	66	272	9.3	11.06	472	3304	1,011,962
329	1.613	89	72	280	10.0	11.05	472	3304	1,015,266
330	1.602	90	66	278	9.6	11.05	472	3304	1,018,570

331	1.612	88	62	278	9.6	11.04	472	3304	1,021,874
332	1.610	90	62	284	9.6	11.04	472	3304	1,025,178
333	1.615	89	60	282	9.6	11.04	472	3304	1,028,482
334	1.422	77	86	282	9.5	11.03	472	3304	1,031,786
335	1.746	51	26	188	9.4	11.03	472	3304	1,035,090
336	1.396	78	88	276	9.8	11.02	472	3304	1,038,394
337	1.419	75	86	278	9.2	11.02	472	3304	1,041,698
338	1.416	78	86	276	9.1	11.01	472	3304	1,045,002
339	1.307	79	50	188	23.0	11.05	472	3304	1,048,306
340	1.667	58	26	172	12.1	11.05	472	3304	1,051,610
341	1.495	82	88	266	9.1	11.04	472	3304	1,054,914
342	1.712	58	24	182	9.1	11.04	472	3304	1,058,218
343	1.469	83	80	264	8.9	11.03	472	3304	1,061,522
344	1.281	86	108	216	9.8	11.03	472	3304	1,064,826
345	1.349	97	122	276	9.0	11.02	472	3304	1,068,130
346	1.240	95	88	252	10.3	11.02	472	3304	1,071,434
347	1.406	86	44	198	9.1	11.01	472	3304	1,074,738
348	1.150	96	86	266	9.7	11.01	472	3304	1,078,042
349	1.256	83	34	192	9.2	11.01	472	3304	1,081,346
350	1.214	102	90	206	8.7	11.00	472	3304	1,084,650
351	1.282	86	72	226	10.2	11.00	472	3304	1,087,954
352	1.709	71	32	148	8.9	10.99	472	3304	1,091,258
353	1.874	76	52	172	9.0	10.99	472	3304	1,094,562
354	1.994	63	42	176	10.3	10.98	472	3304	1,097,866
355	2.138	61	40	176	9.0	10.98	472	3304	1,101,170
356	1.539	74	44	174	9.1	10.97	472	3304	1,104,474
357	1.546	72	38	176	9.0	10.97	472	3304	1,107,778
358	1.902	75	52	176	9.1	10.96	472	3304	1,111,082
359	1.185	92	66	200	10.8	10.96	472	3304	1,114,386
360	1.468	62	34	154	8.9	10.96	472	3304	1,117,690
361	1.178	87	26	186	17.6	10.97	472	3304	1,120,994
362	1.294	92	108	270	8.9	10.97	472	3304	1,124,298
363	1.323	80	72	198	8.9	10.96	472	3304	1,127,602
364	1.808	59	54	186	8.7	10.96	472	3304	1,130,906
365	1.360	83	70	218	9.0	10.95	472	3304	1,134,210
366	1.159	88	28	214	10.1	10.95	472	3304	1,137,514
367	1.554	76	46	182	9.1	10.94	472	3304	1,140,818
368	1.977	61	80	192	9.9	10.94	472	3304	1,144,122
369	2.092	67	74	190	9.2	10.94	472	3304	1,147,426
370	2.027	69	80	192	9.2	10.93	472	3304	1,150,730
371	1.768	68	42	196	9.1	10.93	472	3304	1,154,034
372	1.631	76	66	192	9.2	10.92	472	3304	1,157,338
373	1.665	71	62	194	9.2	10.92	472	3304	1,160,642
374	1.767	58	76	196	9.8	10.91	474	3318	1,163,960
375	1.783	63	80	194	9.1	10.91	474	3318	1,167,278
376	1.931	62	82	192	9.3	10.91	474	3318	1,170,596
377	1.871	64	78	192	9.2	10.90	474	3318	1,173,914
378	2.082	52	34	180	9.1	10.90	474	3318	1,177,232
379	2.077	59	46	182	9.1	10.89	474	3318	1,180,550
380	2.012	60	48	182	9.0	10.89	474	3318	1,183,868
381	2.098	59	46	184	8.9	10.88	474	3318	1,187,186
382	1.833	70	90	194	8.8	10.88	474	3318	1,190,504
383	1.454	88	60	182	9.0	10.87	474	3318	1,193,822
384	1.818	70	94	198	8.8	10.87	476	3332	1,197,154
385	1.844	74	52	206	9.1	10.86	476	3332	1,200,486
386	1.884	74	72	194	10.4	10.86	476	3332	1,203,818
387	1.797	74	72	198	9.1	10.85	476	3332	1,207,150
388	1.811	78	80	192	9.0	10.85	476	3332	1,210,482
389	1.830	79	82	192	9.1	10.85	476	3332	1,213,814
390	2.216	61	46	198	9.2	10.84	476	3332	1,217,146
391	2.225	61	42	196	9.2	10.84	476	3332	1,220,478
392	2.596	57	38	192	9.1	10.83	476	3332	1,223,810
393	1.332	106	62	284	15.1	10.84	476	3332	1,227,142
394	1.351	93	88	276	16.8	10.86	476	3332	1,230,474
395	1.451	74	36	280	9.4	10.85	476	3332	1,233,806
396	1.394	92	86	266	9.4	10.85	476	3332	1,237,138
397	1.445	87	80	270	9.3	10.85	476	3332	1,240,470
398	1.422	72	40	284	9.4	10.84	476	3332	1,243,802

399	1.578	64	24	176	9.4	10.84	476	3332	1,247,134
400	1.654	64	26	178	9.3	10.84	476	3332	1,250,466
401	1.419	90	90	276	9.3	10.83	476	3332	1,253,798
402	1.386	89	82	272	9.3	10.83	476	3332	1,257,130
403	1.389	93	90	272	9.2	10.82	476	3332	1,260,462
404	1.577	88	92	276	9.6	10.82	482	3374	1,263,836
405	1.564	89	96	276	9.4	10.82	482	3374	1,267,210
406	1.461	70	28	178	10.9	10.82	482	3374	1,270,584
407	1.441	94	76	276	10.2	10.82	482	3374	1,273,958
408	1.419	94	80	284	10.8	10.82	482	3374	1,277,332
409	1.544	80	100	284	10.5	10.82	482	3374	1,280,706
410	1.568	86	104	268	7.4	10.81	482	3374	1,284,080
411	1.312	98	66	278	12.3	10.81	482	3374	1,287,454
412	1.310	98	64	276	10.2	10.81	482	3374	1,290,828
413	1.322	96	64	270	10.2	10.81	482	3374	1,294,202
414	1.322	98	64	278	9.6	10.81	484	3388	1,297,590
415	1.319	96	64	270	10.4	10.80	484	3388	1,300,978
416	1.343	96	54	266	10.3	10.80	484	3388	1,304,366
417	1.386	94	60	274	9.7	10.80	484	3388	1,307,754
418	1.225	93	48	248	10.4	10.80	484	3388	1,311,142
419	1.387	95	54	272	11.0	10.80	484	3388	1,314,530
420	1.349	97	62	272	9.1	10.80	484	3388	1,317,918
421	1.312	100	64	284	8.4	10.79	484	3388	1,321,306
422	1.314	99	62	282	7.7	10.78	484	3388	1,324,694
423	1.327	96	64	276	7.8	10.78	486	3402	1,328,096
424	1.439	95	86	282	11.6	10.78	486	3402	1,331,498
425	1.397	93	86	278	11.3	10.78	486	3402	1,334,900
426	1.422	93	80	264	9.7	10.78	486	3402	1,338,302
427	1.412	95	82	278	9.7	10.77	486	3402	1,341,704
428	1.405	95	86	270	9.6	10.77	486	3402	1,345,106
429	1.592	95	68	276	12.5	10.78	486	3402	1,348,508
430	1.573	95	68	272	9.8	10.77	486	3402	1,351,910
431	1.577	96	70	276	9.7	10.77	486	3402	1,355,312
432	1.559	94	76	272	9.7	10.77	486	3402	1,358,714
433	1.493	96	72	276	11.1	10.77	487	3409	1,362,123
434	1.594	92	68	262	7.7	10.76	487	3409	1,365,532
435	1.626	94	68	278	12.6	10.77	487	3409	1,368,941
436	1.631	93	68	272	8.0	10.76	487	3409	1,372,350
437	1.642	93	68	270	7.8	10.75	487	3409	1,375,759
438	1.612	87	86	260	10.3	10.75	487	3409	1,379,168
439	1.609	91	96	262	9.4	10.75	489	3423	1,382,591
440	1.640	93	92	264	9.6	10.75	489	3423	1,386,014
441	1.669	88	96	264	9.7	10.74	489	3423	1,389,437
442	1.625	89	98	266	9.4	10.74	489	3423	1,392,860
443	1.691	80	76	244	9.5	10.74	489	3423	1,396,283
444	1.667	87	78	252	10.7	10.74	489	3423	1,399,706
445	1.666	87	82	268	10.0	10.74	491	3437	1,403,143
446	1.457	84	72	268	9.4	10.73	491	3437	1,406,580
447	1.465	83	78	264	9.5	10.73	491	3437	1,410,017
448	1.255	98	92	262	9.1	10.73	491	3437	1,413,454
449	1.509	84	70	276	9.4	10.72	491	3437	1,416,891
450	1.528	81	64	272	9.3	10.72	491	3437	1,420,328
451	1.395	84	76	276	10.4	10.72	491	3437	1,423,765
452	1.487	85	78	276	9.3	10.72	491	3437	1,427,202
453	1.538	81	82	272	9.3	10.71	491	3437	1,430,639
454	1.616	89	90	268	11.2	10.71	491	3437	1,434,076
455	1.525	93	94	272	9.3	10.71	491	3437	1,437,513
456	1.489	92	98	268	9.2	10.71	491	3437	1,440,950
457	1.533	92	90	272	9.1	10.70	491	3437	1,444,387
458	1.467	92	72	274	9.2	10.70	491	3437	1,447,824
459	1.251	114	104	270	9.2	10.70	491	3437	1,451,261
460	1.321	97	122	276	9.2	10.70	491	3437	1,454,698
461	1.161	92	24	162	9.8	10.69	493	3451	1,458,149
462	1.423	88	42	198	9.1	10.69	493	3451	1,461,600
463	1.188	98	66	200	9.9	10.69	493	3451	1,465,051
464	1.216	103	94	208	9.8	10.69	493	3451	1,468,502
465	1.714	67	36	148	9.7	10.68	493	3451	1,471,953
466	1.843	75	50	172	9.1	10.68	493	3451	1,475,404

467	1.844	75	48	172	9.0	10.68	493	3451	1,478,855
468	2.052	62	50	176	9.1	10.67	493	3451	1,482,306
469	1.497	74	42	174	9.7	10.67	493	3451	1,485,757
470	1.472	72	50	176	9.1	10.67	493	3451	1,489,208
471	1.520	78	46	182	9.8	10.67	493	3451	1,492,659
472	1.797	77	52	176	9.3	10.66	493	3451	1,496,110
473	1.210	93	28	172	9.8	10.66	493	3451	1,499,561
474	1.194	101	60	184	18.5	10.68	493	3451	1,503,012
475	1.388	66	34	184	9.7	10.68	493	3451	1,506,463
476	1.172	96	32	198	14.6	10.68	493	3451	1,509,914
477	1.246	87	50	204	15.4	10.69	493	3451	1,513,365
478	1.388	81	38	186	9.0	10.69	493	3451	1,516,816
479	1.819	61	54	192	8.7	10.69	493	3451	1,520,267
480	1.215	90	26	206	9.1	10.68	493	3451	1,523,718
481	1.554	75	46	182	9.8	10.68	493	3451	1,527,169
482	1.549	74	40	182	9.2	10.68	493	3451	1,530,620
483	1.938	65	80	188	9.2	10.68	493	3451	1,534,071
484	1.473	83	86	148	9.1	10.67	493	3451	1,537,522
485	2.058	69	74	192	9.2	10.67	493	3451	1,540,973
486	1.739	69	46	198	9.1	10.67	493	3451	1,544,424
487	1.711	70	50	194	9.2	10.66	493	3451	1,547,875
488	1.641	74	66	192	9.3	10.66	493	3451	1,551,326
489	1.668	72	64	194	9.2	10.66	493	3451	1,554,777
490	1.772	57	72	194	9.2	10.65	493	3451	1,558,228
491	1.765	65	80	194	9.1	10.65	493	3451	1,561,679
492	1.920	63	80	192	9.3	10.65	493	3451	1,565,130
493	1.865	64	80	192	9.9	10.65	493	3451	1,568,581
494	2.070	53	38	184	9.1	10.64	493	3451	1,572,032
495	2.068	59	46	182	9.2	10.64	493	3451	1,575,483
496	2.048	61	46	182	9.2	10.64	493	3451	1,578,934
497	1.998	62	48	182	9.2	10.63	493	3451	1,582,385
498	2.236	56	36	190	9.0	10.63	493	3451	1,585,836
499	2.206	56	28	192	9.0	10.63	493	3451	1,589,287
500	2.140	63	46	192	9.1	10.63	493	3451	1,592,738
501	1.794	70	92	192	9.0	10.62	493	3451	1,596,189
502	1.320	99	68	208	9.0	10.62	493	3451	1,599,640
503	1.730	73	94	192	9.1	10.62	493	3451	1,603,091
504	1.751	75	96	192	9.0	10.61	493	3451	1,606,542
505	1.896	65	96	198	8.9	10.61	493	3451	1,609,993
506	1.861	66	92	198	8.9	10.61	493	3451	1,613,444
507	2.046	63	62	206	9.1	10.60	493	3451	1,616,895
508	1.938	68	62	208	9.2	10.60	493	3451	1,620,346
509	1.816	75	50	208	9.2	10.60	493	3451	1,623,797
510	1.793	74	54	206	9.1	10.59	493	3451	1,627,248
511	1.892	67	60	208	9.3	10.59	495	3465	1,630,713
512	1.930	67	42	208	9.2	10.59	495	3465	1,634,178
513	1.608	52	26	142	9.2	10.59	495	3465	1,637,643
514	1.662	75	62	198	9.1	10.58	495	3465	1,641,108
515	1.631	73	64	198	9.2	10.58	495	3465	1,644,573
516	1.678	75	72	206	9.3	10.58	495	3465	1,648,038
517	1.643	73	74	204	9.3	10.58	495	3465	1,651,503
518	1.899	78	72	198	9.3	10.57	495	3465	1,654,968
519	1.870	75	70	198	9.3	10.57	495	3465	1,658,433
520	1.776	80	80	192	8.9	10.57	495	3465	1,661,898
521	1.850	77	78	192	9.2	10.56	495	3465	1,665,363
522	1.789	74	78	192	9.3	10.56	495	3465	1,668,828
523	2.189	63	44	198	9.3	10.56	495	3465	1,672,293
524	2.120	63	42	198	9.3	10.56	495	3465	1,675,758
525	1.406	94	98	278	7.3	10.55	495	3465	1,679,223
526	1.334	93	106	268	7.0	10.54	495	3465	1,682,688
527	1.621	67	34	188	7.1	10.54	495	3465	1,686,153
528	1.365	88	100	260	7.1	10.53	495	3465	1,689,618
529	1.380	88	92	262	7.0	10.52	495	3465	1,693,083
530	1.792	70	26	182	7.1	10.52	495	3465	1,696,548
531	1.596	77	98	266	7.3	10.51	495	3465	1,700,013
532	1.575	78	100	268	7.5	10.51	495	3465	1,703,478
533	1.546	79	106	272	7.4	10.50	495	3465	1,706,943
534	1.558	76	96	264	7.3	10.49	495	3465	1,710,408

535	1.594	76	98	262	7.3	10.49	495	3465	1,713,873
536	1.506	62	24	188	7.4	10.48	495	3465	1,717,338
537	1.586	78	98	266	7.4	10.48	495	3465	1,720,803
538	1.600	77	98	266	7.4	10.47	495	3465	1,724,268
539	1.537	83	74	274	7.3	10.47	495	3465	1,727,733
540	1.484	75	60	272	7.6	10.46	495	3465	1,731,198
541	1.328	86	56	264	7.5	10.46	495	3465	1,734,663
542	1.560	67	60	182	8.0	10.45	495	3465	1,738,128
543	1.517	82	68	264	9.7	10.45	495	3465	1,741,593
544	1.497	83	70	266	7.6	10.44	495	3465	1,745,058
545	1.547	81	68	268	7.4	10.44	495	3465	1,748,523
546	1.560	83	72	272	7.5	10.43	495	3465	1,751,988
547	1.598	81	72	266	7.5	10.43	495	3465	1,755,453
548	1.578	82	70	266	7.5	10.42	495	3465	1,758,918
549	1.394	82	70	276	7.3	10.42	495	3465	1,762,383
550	1.484	89	86	262	7.6	10.41	495	3465	1,765,848
551	1.414	76	34	218	12.7	10.42	495	3465	1,769,313
552	1.434	81	86	274	11.1	10.42	495	3465	1,772,778
553	1.374	86	76	272	10.1	10.42	495	3465	1,776,243
554	1.540	65	24	168	7.2	10.41	495	3465	1,779,708
555	1.529	68	36	174	7.2	10.40	495	3465	1,783,173
556	1.475	74	64	174	9.8	10.40	495	3465	1,786,638
557	1.291	93	86	272	8.5	10.40	495	3465	1,790,103
558	1.403	79	62	188	11.8	10.40	495	3465	1,793,568
559	1.553	91	66	212	12.8	10.41	495	3465	1,797,033
560	1.331	96	90	238	9.3	10.41	495	3465	1,800,498
561	1.523	66	24	186	9.3	10.40	495	3465	1,803,963
562	1.580	90	92	284	10.8	10.40	495	3465	1,807,428
563	1.561	88	100	266	9.3	10.40	495	3465	1,810,893
564	1.756	90	100	268	9.6	10.40	495	3465	1,814,358
565	1.774	88	96	268	9.6	10.40	495	3465	1,817,823
566	1.540	82	30	168	20.3	10.42	495	3465	1,821,288
567	2.050	56	24	172	20.7	10.43	495	3465	1,824,753
568	1.743	91	88	260	10.8	10.44	495	3465	1,828,218
569	1.724	93	92	262	9.6	10.43	495	3465	1,831,683
570	1.734	93	98	262	9.6	10.43	495	3465	1,835,148
571	1.695	94	102	266	9.6	10.43	495	3465	1,838,613
572	1.671	57	22	162	9.2	10.43	495	3465	1,842,078
573	1.400	61	36	154	9.0	10.43	495	3465	1,845,543
574	1.643	58	22	166	16.6	10.44	495	3465	1,849,008
575	1.561	63	34	172	13.7	10.44	495	3465	1,852,473
576	1.251	101	86	264	10.6	10.44	495	3465	1,855,938
577	1.408	74	36	186	11.9	10.45	495	3465	1,859,403
578	1.582	61	36	164	9.1	10.44	495	3465	1,862,868
579	1.153	100	74	170	14.0	10.45	495	3465	1,866,333
580	1.232	93	106	266	18.2	10.46	495	3465	1,869,798
581	1.705	57	22	170	9.6	10.46	495	3465	1,873,263
582	1.619	59	46	176	10.4	10.46	495	3465	1,876,728
583	1.675	62	46	180	9.7	10.46	495	3465	1,880,193
584	1.668	62	42	182	9.3	10.46	495	3465	1,883,658
585	1.193	83	28	210	9.8	10.46	495	3465	1,887,123
586	1.616	76	96	276	11.0	10.46	499	3493	1,890,616
587	1.571	78	100	266	9.7	10.46	499	3493	1,894,109
588	1.460	79	72	262	9.4	10.45	499	3493	1,897,602
589	1.406	64	86	182	9.3	10.45	499	3493	1,901,095
590	1.631	83	72	266	9.9	10.45	503	3521	1,904,616
591	1.419	92	114	284	12.1	10.45	503	3521	1,908,137
592	1.460	90	100	272	11.5	10.46	505	3535	1,911,672
593	1.620	80	90	252	10.2	10.46	505	3535	1,915,207
594	1.625	77	102	260	10.8	10.46	505	3535	1,918,742
595	1.555	73	90	246	11.9	10.46	505	3535	1,922,277
596	1.637	78	100	264	12.0	10.46	505	3535	1,925,812
597	1.342	87	50	234	11.9	10.46	505	3535	1,929,347
598	1.285	82	22	178	9.4	10.46	505	3535	1,932,882
599	1.849	56	62	206	9.4	10.46	505	3535	1,936,417
600	1.559	78	108	276	9.2	10.46	505	3535	1,939,952
601	1.620	75	114	262	10.8	10.46	505	3535	1,943,487
602	1.577	79	114	284	9.3	10.46	505	3535	1,947,022

603	3.503	28	30	148	9.2	10.45	505	3535	1,950,557
604	1.630	76	122	274	9.4	10.45	505	3535	1,954,092
605	1.625	64	66	178	9.2	10.45	505	3535	1,957,627
606	1.559	91	92	264	13.8	10.46	505	3535	1,961,162
607	1.566	91	86	272	10.2	10.46	505	3535	1,964,697
608	1.429	97	90	284	9.6	10.45	505	3535	1,968,232
609	1.718	69	26	166	13.5	10.46	505	3535	1,971,767
610	1.277	109	100	202	9.2	10.46	505	3535	1,975,302
611	1.234	91	50	156	9.4	10.46	505	3535	1,978,837
612	1.208	94	64	198	9.3	10.45	505	3535	1,982,372
613	1.231	97	66	202	9.3	10.45	505	3535	1,985,907
614	1.368	100	72	220	11.0	10.45	505	3535	1,989,442
615	2.009	54	70	156	18.3	10.47	505	3535	1,992,977
616	1.726	53	96	160	8.8	10.46	505	3535	1,996,512
617	1.857	62	78	206	9.1	10.46	505	3535	2,000,047
618	1.923	63	80	208	9.2	10.46	505	3535	2,003,582
619	1.685	78	86	214	9.3	10.46	505	3535	2,007,117
620	1.656	76	86	212	9.4	10.46	505	3535	2,010,652
621	1.665	74	88	214	9.5	10.45	505	3535	2,014,187
622	2.188	54	88	160	11.7	10.46	505	3535	2,017,722
623	1.643	76	112	210	9.0	10.45	505	3535	2,021,257
624	2.175	63	76	162	9.2	10.45	505	3535	2,024,792
625	2.276	52	94	186	9.3	10.45	505	3535	2,028,327
626	2.197	53	98	184	10.1	10.45	505	3535	2,031,862
627	1.897	64	110	214	9.4	10.45	505	3535	2,035,397
628	1.843	59	108	212	9.2	10.45	505	3535	2,038,932
629	1.890	65	112	212	9.3	10.44	505	3535	2,042,467
630	1.442	93	34	254	9.3	10.44	505	3535	2,046,002
631	1.749	66	68	192	9.3	10.44	505	3535	2,049,537
632	1.777	65	66	192	9.3	10.44	505	3535	2,053,072
633	1.767	62	64	192	9.3	10.44	505	3535	2,056,607
634	1.709	66	72	188	9.3	10.43	505	3535	2,060,142
635	1.722	64	70	188	9.4	10.43	505	3535	2,063,677
636	1.743	63	64	192	9.3	10.43	505	3535	2,067,212
637	1.488	95	78	282	9.1	10.43	505	3535	2,070,747
638	1.778	93	88	176	8.9	10.43	505	3535	2,074,282
639	1.799	90	88	172	9.1	10.42	505	3535	2,077,817
640	1.785	93	88	176	9.1	10.42	505	3535	2,081,352
641	1.770	90	86	172	9.0	10.42	505	3535	2,084,887
642	1.349	91	78	202	8.9	10.42	505	3535	2,088,422
643	1.358	89	78	198	8.9	10.42	505	3535	2,091,957
644	1.406	91	78	200	9.0	10.41	505	3535	2,095,492
645	1.359	89	78	202	9.0	10.41	505	3535	2,099,027
646	1.439	81	82	200	9.0	10.41	505	3535	2,102,562
647	1.459	81	84	196	9.9	10.41	507	3549	2,106,111
648	1.436	76	78	190	9.1	10.41	507	3549	2,109,660
649	2.494	60	102	208	9.2	10.40	507	3549	2,113,209
650	2.495	58	96	208	9.3	10.40	507	3549	2,116,758
651	2.512	60	96	212	9.3	10.40	507	3549	2,120,307
652	2.318	62	94	214	9.3	10.40	507	3549	2,123,856
653	2.170	56	78	206	9.3	10.40	507	3549	2,127,405
654	1.802	78	46	198	9.3	10.40	507	3549	2,130,954
655	1.778	76	38	198	9.3	10.39	507	3549	2,134,503
656	1.816	74	46	202	9.3	10.39	507	3549	2,138,052
657	1.787	73	44	206	9.2	10.39	507	3549	2,141,601
658	1.745	72	40	202	9.3	10.39	507	3549	2,145,150
659	1.750	71	44	202	9.3	10.39	507	3549	2,148,699
660	2.010	57	40	208	9.2	10.39	507	3549	2,152,248
661	2.032	54	40	208	9.3	10.38	507	3549	2,155,797
662	1.871	56	40	208	9.3	10.38	507	3549	2,159,346
663	1.546	61	88	156	9.2	10.38	507	3549	2,162,895
664	1.874	59	40	208	9.4	10.38	507	3549	2,166,444
665	2.012	72	54	200	9.3	10.38	507	3549	2,169,993
666	2.029	68	48	198	9.3	10.38	507	3549	2,173,542
667	2.017	70	52	200	9.3	10.37	507	3549	2,177,091
668	2.040	68	54	198	9.2	10.37	507	3549	2,180,640
669	2.246	82	58	188	9.2	10.37	507	3549	2,184,189
670	2.250	83	60	188	9.3	10.37	507	3549	2,187,738

671	2.162	84	56	186	9.3	10.37	507	3549	2,191,287
672	2.281	74	52	188	9.3	10.37	507	3549	2,194,836
673	2.203	81	48	188	9.2	10.36	507	3549	2,198,385
674	2.271	65	56	176	9.2	10.36	507	3549	2,201,934
675	2.293	64	54	172	9.1	10.36	507	3549	2,205,483
676	2.174	63	50	176	9.0	10.36	507	3549	2,209,032
677	2.563	55	50	176	9.2	10.36	507	3549	2,212,581
678	2.570	57	46	176	9.2	10.35	507	3549	2,216,130
679	2.714	49	44	182	9.1	10.35	507	3549	2,219,679
680	2.573	52	44	182	8.9	10.35	507	3549	2,223,228
681	2.077	93	62	196	9.2	10.35	507	3549	2,226,777
682	2.131	89	56	198	9.1	10.35	507	3549	2,230,326
683	2.155	89	66	198	9.1	10.35	507	3549	2,233,875
684	1.796	89	62	168	8.9	10.34	507	3549	2,237,424
685	2.301	83	58	198	9.1	10.34	507	3549	2,240,973
686	2.241	81	58	198	9.1	10.34	507	3549	2,244,522
687	2.229	79	48	200	9.1	10.34	507	3549	2,248,071
688	2.238	57	42	188	9.3	10.34	507	3549	2,251,620
689	2.138	60	42	184	9.9	10.34	507	3549	2,255,169
690	2.141	58	44	188	10.5	10.34	507	3549	2,258,718
691	2.053	66	44	192	9.8	10.34	507	3549	2,262,267
692	1.863	73	42	180	9.3	10.33	507	3549	2,265,816
693	1.993	72	48	178	9.1	10.33	507	3549	2,269,365
694	1.985	75	46	178	9.7	10.33	507	3549	2,272,914
695	1.350	122	114	238	9.1	10.33	507	3549	2,276,463
696	2.154	77	50	182	9.1	10.33	507	3549	2,280,012
697	2.105	78	48	182	9.2	10.33	507	3549	2,283,561
698	2.194	67	62	200	36.3	10.36	507	3549	2,287,110
699	2.170	70	62	198	9.2	10.36	507	3549	2,290,659
700	2.085	72	62	200	9.1	10.36	507	3549	2,294,208
701	2.161	71	60	200	9.8	10.36	507	3549	2,297,757
702	2.246	73	64	200	9.3	10.36	507	3549	2,301,306
703	1.364	69	56	158	8.9	10.36	507	3549	2,304,855
704	1.854	58	42	206	9.1	10.35	507	3549	2,308,404
705	1.575	79	38	280	9.1	10.35	507	3549	2,311,953
706	2.531	67	104	214	9.3	10.35	507	3549	2,315,502
707	2.515	65	102	212	9.3	10.35	507	3549	2,319,051
708	2.135	87	90	202	9.0	10.35	507	3549	2,322,600
709	2.121	90	96	202	9.1	10.35	509	3563	2,326,163
710	1.645	74	64	214	8.9	10.34	511	3577	2,329,740
711	1.667	74	64	212	9.1	10.34	511	3577	2,333,317
712	2.233	63	54	208	9.3	10.34	511	3577	2,336,894
713	2.154	64	56	206	9.3	10.34	511	3577	2,340,471
714	2.044	68	62	206	9.1	10.34	511	3577	2,344,048
715	2.559	77	84	200	9.3	10.34	511	3577	2,347,625
716	2.567	78	94	200	9.3	10.33	511	3577	2,351,202
717	2.290	55	50	154	9.3	10.33	511	3577	2,354,779
718	2.434	63	96	198	9.3	10.33	511	3577	2,358,356
719	2.488	60	86	194	9.4	10.33	511	3577	2,361,933
720	2.874	60	104	208	9.4	10.33	511	3577	2,365,510
721	2.790	62	108	208	9.3	10.33	511	3577	2,369,087
722	2.716	66	110	208	9.2	10.33	511	3577	2,372,664
723	2.432	48	96	152	9.2	10.32	511	3577	2,376,241
724	2.814	53	96	208	9.4	10.32	511	3577	2,379,818
725	2.771	55	94	208	9.4	10.32	511	3577	2,383,395
726	2.917	50	88	208	9.3	10.32	511	3577	2,386,972
727	1.414	71	108	246	9.2	10.32	511	3577	2,390,549
728	2.052	70	88	200	9.3	10.32	511	3577	2,394,126
729	2.172	66	78	202	9.3	10.32	511	3577	2,397,703
730	2.205	61	88	206	9.4	10.31	511	3577	2,401,280
731	2.422	64	88	218	9.4	10.31	511	3577	2,404,857
732	2.364	63	104	214	9.1	10.31	511	3577	2,408,434
733	2.461	73	108	218	9.4	10.31	511	3577	2,412,011
734	2.432	68	98	218	9.5	10.31	511	3577	2,415,588
735	2.623	57	72	200	9.4	10.31	511	3577	2,419,165
736	2.747	55	86	202	9.2	10.31	511	3577	2,422,742
737	2.777	57	96	202	9.2	10.30	511	3577	2,426,319
738	2.340	65	86	200	9.2	10.30	511	3577	2,429,896

739	2.312	64	90	198	9.2	10.30	511	3577	2,433,473
740	2.315	73	70	198	9.1	10.30	511	3577	2,437,050
741	2.173	76	64	198	9.0	10.30	511	3577	2,440,627
742	2.264	57	62	202	9.1	10.30	511	3577	2,444,204
743	2.204	63	62	202	9.3	10.30	511	3577	2,447,781
744	2.101	64	64	206	9.3	10.29	511	3577	2,451,358
745	2.710	76	56	202	9.3	10.29	511	3577	2,454,935
746	2.415	80	56	206	9.1	10.29	511	3577	2,458,512
747	2.274	84	54	200	8.9	10.29	511	3577	2,462,089
748	2.643	71	56	198	8.9	10.29	511	3577	2,465,666
749	2.598	47	88	206	9.3	10.29	511	3577	2,469,243
750	2.610	51	94	210	9.4	10.28	511	3577	2,472,820
751	2.690	49	88	206	9.3	10.28	511	3577	2,476,397
752	2.360	56	80	202	9.4	10.28	511	3577	2,479,974
753	2.570	53	80	206	9.3	10.28	513	3591	2,483,565
754	2.494	51	78	202	9.2	10.28	513	3591	2,487,156
755	2.372	87	72	194	8.9	10.28	565	3955	2,491,111
756	2.348	86	78	194	8.8	10.28	565	3955	2,495,066
757	2.092	53	78	156	8.9	10.27	565	3955	2,499,021
758	2.873	62	102	208	9.4	10.27	565	3955	2,502,976
759	1.699	71	104	202	8.7	10.27	565	3955	2,506,931
760	2.132	66	86	202	9.6	10.27	565	3955	2,510,886
761	2.274	61	86	206	9.6	10.27	565	3955	2,514,841
762	1.266	111	98	206	10.1	10.27	565	3955	2,518,796
763	1.251	92	50	156	11.0	10.27	565	3955	2,522,751
764	1.222	98	64	198	10.4	10.27	565	3955	2,526,706
765	1.390	100	72	222	8.9	10.27	565	3955	2,530,661
766	1.445	67	90	206	16.8	10.28	565	3955	2,534,616
767	1.676	78	88	164	9.3	10.28	565	3955	2,538,571
768	2.092	53	94	182	9.7	10.27	565	3955	2,542,526
769	1.479	82	80	198	9.4	10.27	565	3955	2,546,481
770	1.403	80	80	192	9.3	10.27	565	3955	2,550,436
771	2.500	59	100	210	9.3	10.27	565	3955	2,554,391
772	2.437	59	98	208	9.6	10.27	565	3955	2,558,346
773	2.458	62	98	208	9.6	10.27	565	3955	2,562,301
774	2.197	64	94	214	9.6	10.27	565	3955	2,566,256
775	2.361	60	98	212	9.5	10.27	565	3955	2,570,211
776	2.014	55	40	208	9.4	10.27	565	3955	2,574,166
777	2.021	55	40	208	9.5	10.27	565	3955	2,578,121
778	2.248	76	54	188	9.4	10.26	565	3955	2,582,076
779	1.944	84	36	192	9.4	10.26	565	3955	2,586,031
780	2.284	64	54	172	9.4	10.26	565	3955	2,589,986
781	2.232	62	48	172	9.4	10.26	565	3955	2,593,941
782	2.508	56	52	180	9.4	10.26	565	3955	2,597,896
783	2.731	46	44	184	9.2	10.26	565	3955	2,601,851
784	2.453	54	42	182	9.3	10.26	565	3955	2,605,806
785	2.116	59	40	188	9.3	10.26	565	3955	2,609,761
786	2.146	58	38	186	9.4	10.25	565	3955	2,613,716
787	1.830	73	44	190	9.3	10.25	565	3955	2,617,671
788	1.351	101	78	282	8.8	10.25	565	3955	2,621,626
789	1.613	53	20	160	9.1	10.25	565	3955	2,625,581
790	1.713	60	32	206	9.3	10.25	565	3955	2,629,536
791	2.447	68	112	212	9.4	10.25	565	3955	2,633,491
792	1.626	76	38	276	9.7	10.25	565	3955	2,637,446
793	2.525	68	96	212	9.6	10.25	565	3955	2,641,401
794	1.357	111	42	132	34.1	10.28	565	3955	2,645,356
795	2.153	67	86	202	9.4	10.28	565	3955	2,649,311
796	2.111	71	98	198	9.6	10.27	565	3955	2,653,266
797	2.160	67	92	202	9.6	10.27	565	3955	2,657,221
798	2.239	62	86	206	9.4	10.27	565	3955	2,661,176
799	1.983	75	86	202	9.4	10.27	565	3955	2,665,131
800	1.959	71	72	206	9.6	10.27	565	3955	2,669,086
801	1.929	59	74	162	9.6	10.27	565	3955	2,673,041
802	2.364	69	108	218	9.6	10.27	565	3955	2,676,996
803	2.515	57	102	218	9.5	10.27	565	3955	2,680,951
804	2.330	62	96	212	9.5	10.27	565	3955	2,684,906
805	2.391	60	102	214	9.6	10.27	565	3955	2,688,861
806	2.588	72	54	198	8.9	10.26	565	3955	2,692,816

807	2.343	66	48	188	9.4	10.26	565	3955	2,696,771
808	2.313	66	50	188	9.5	10.26	565	3955	2,700,726
809	2.108	51	56	154	9.2	10.26	565	3955	2,704,681
810	1.970	50	54	148	9.3	10.26	565	3955	2,708,636
811	2.279	64	86	192	9.5	10.26	565	3955	2,712,591
812	2.501	50	96	202	9.6	10.26	565	3955	2,716,546
813	2.596	53	94	206	10.3	10.26	565	3955	2,720,501
814	2.429	52	94	204	10.3	10.26	565	3955	2,724,456
815	1.266	113	126	284	9.1	10.26	565	3955	2,728,411

ANNEX 5

APPENDIX E

ENROLLMENTS FILE

OCTOBER 21..NOVEMBER 16, 1994

TEST #	FILE #	NAME	EYE	ID #	DATE / TIME
1	406	Williams, G.	R	N/A	Fri Oct 21 14:03:57 1994
2	407	Williams, G.	L	N/A	Fri Oct 21 14:04:48 1994
3	408	Thurston, R.	R	N/A	Sat Oct 22 11:07:41 1994
4	409	Thurston, R.	L	N/A	Sat Oct 22 11:08:42 1994
5	410	Thurston, J.	R	N/A	Sat Oct 22 11:16:52 1994
6	411	Thurston, J.	L	N/A	Sat Oct 22 11:18:24 1994
7.	412	Richards, J.	R	N/A	Sat Oct 22 11:25:36 1994
8	413	Richards, J.	L	N/A	Sat Oct 22 11:26:35 1994
9	414	Thurston K.	R	N/A	Sat Oct 22 11:32:41 1994
10	415	Richards, D.	R	N/A	Sat Oct 22 11:39:59 1994
11	416	Richards, D.	L	N/A	Sat Oct 22 11:41:04 1994
12	417	Lee, J.	R	N/A	Sun Oct 23 13:40:34 1994
13	418	Lee, J.	L	N/A	Sun Oct 23 13:42:04 1994
14	419	Gregorio, J.	R	N/A	Mon Oct 24 05:14:13 1994
15	420	Gregorio, J.	L	N/A	Mon Oct 24 05:15:05 1994
16	421	Ansell, S.	R	N/A	Mon Oct 24 05:39:01 1994
17	422	Mackinnon,	R	N/A	Mon Oct 24 06:08:59 1994
18	423	Mackinnon,	L	N/A	Mon Oct 24 06:09:54 1994
19	424	Krausz, G..	R	N/A	Mon Oct 24 07:08:53 1994
20	425	Krausz, G.	L	N/A	Mon Oct 24 07:09:55 1994
21	426	Brown, k.	R	N/A	Mon Oct 24 07:41:50 1994
22	427	Brown, k.	L	N/A	Mon Oct 24 07:42:43 1994
23	428	Gregorio, P.	R	N/A	Mon Oct 24 07:42:43 1994
24	429	Gregorio, P.	L	N/A	Mon Oct 24 07:42:43 1994
25	430	Sasala, S.	R	N/A	Mon Oct 24 07:42:43 1994
26	431	Sasala, S.	L	N/A	Mon Oct 24 07:42:43 1994
27	432	FitzMaurice,	R	N/A	Mon Oct 24 07:42:43 1994
28	433	FitzMaurice,	L	N/A	Mon Oct 24 07:42:43 1994
29	434	Ryan, P.	R	N/A	Mon Oct 24 07:42:43 1994
30	435	Coffey, J.	R	N/A	Tue Oct 25 05:00:40 1994
31	436	Coffey, J.	L	N/A	Tue Oct 25 05:00:40 1994
32	437	Aretino, J.	R	N/A	Tue Oct 25 05:00:40 1994
33	438	Aretino, J.	L	N/A	Tue Oct 25 05:00:40 1994
34	439	Gray, D.	R	N/A	Tue Oct 25 05:00:40 1994
35	440	Gray, D.	L	N/A	Tue Oct 25 05:00:40 1994
36	441	Howard, R.	R	N/A	Tue Oct 25 05:00:40 1994
37	442	Howard, R.	R	N/A	Tue Oct 25 05:00:40 1994
38	443	Howard, R.	L	N/A	Tue Oct 25 05:00:40 1994
39	444	Vol #14	L	N/A	Thu Oct 27 04:51:38 1994
40	445	Vol #28	R	N/A	Thu Oct 27 04:51:38 1994
41	446	Vol #28	L	N/A	Thu Oct 27 04:51:38 1994
42	447	Kuhla, B.	R	N/A	Thu Oct 27 04:51:38 1994
43	448	Kuhla, B.	L	N/A	Thu Oct 27 04:51:38 1994
44	449	Gore, J.	R	N/A	Thu Oct 27 04:51:38 1994
45	450	Gore, J.	L	N/A	Thu Oct 27 04:51:38 1994
46	451	Snyder, J.	R	N/A	Thu Oct 27 04:51:38 1994
47	452	Snyder, J.	L	N/A	Thu Oct 27 04:51:38 1994
48	453	Snyder, J.	R	N/A	Thu Oct 27 04:51:38 1994
49	454	Quinn, R.	R	N/A	Thu Oct 27 04:51:38 1994
50	455	Quinn, R.	L	N/A	Thu Oct 27 04:51:38 1994
51	456	Protos, A	L	N/A	Mon Oct 31 16:09:57 1994
52	457	Protos, A	R	N/A	Mon Oct 31 16:09:57 1994
53	458	Vol #1	R	N/A	Mon Oct 31 16:09:57 1994
54	459	Vol #1	L	N/A	Mon Oct 31 16:09:57 1994
55	460	Vol #2	L	N/A	Mon Oct 31 16:09:57 1994

56	461	Vol #2	L	N/A	Mon Oct 31 16:09:57 1994
57	462	vol #4	R	N/A	Mon Oct 31 16:09:57 1994
58	463	vol #4	L	N/A	Mon Oct 31 16:09:57 1994
59	464	Vol #8	R	N/A	Mon Oct 31 16:09:57 1994
60	465	Vol #8	L	N/A	Mon Oct 31 16:09:57 1994
61	466	Vol #3	R	N/A	Mon Oct 31 16:09:57 1994
62	467	Vol #3	L	N/A	Mon Oct 31 16:09:57 1994
63	468	Vol #15	R	N/A	Mon Oct 31 16:09:57 1994
64	469	Vol #15	L	N/A	Mon Oct 31 16:09:57 1994
65	470	Vol #16	L	N/A	Mon Oct 31 16:09:57 1994
66	471	Vol #17	R	N/A	Mon Oct 31 16:09:57 1994
67	472	Vol #17	L	N/A	Mon Oct 31 16:09:57 1994
68	473	Siedlarz P.	R	N/A	Tue Nov 01 16:01:26 1994
69	474	Siedlarz P.	L	N/A	Tue Nov 01 16:01:26 1994
70	475	Lorna	R	N/A	Tue Nov 01 16:01:26 1994
71	476	Lorna	L	N/A	Tue Nov 01 16:01:26 1994
72	477	Vol #29	R	N/A	Wed Nov 02 13:21:53 1994
73	478	Vol #29	L	N/A	Wed Nov 02 13:21:53 1994
74	479	Vol #29	R	N/A	Wed Nov 02 13:21:53 1994
75	480	Whittle, T.	R	N/A	Wed Nov 02 13:21:53 1994
76	481	Whittle, T.	L	N/A	Wed Nov 02 13:21:53 1994
77	482	Whittle, T.	L	N/A	Wed Nov 02 13:21:53 1994
78	483	McHugh, J.	R	N/A	Wed Nov 02 13:21:53 1994
79	484	McHugh, J.	L	N/A	Wed Nov 02 13:21:53 1994
80	485	Siedlarz, J.	R	N/A	Wed Nov 02 13:21:53 1994
81	486	Siedlarz, J.	L	N/A	Wed Nov 02 13:21:53 1994
82	487	Nelson, J.	R	N/A	Wed Nov 02 13:21:53 1994
83	488	Donohue, J.	R	N/A	Wed Nov 02 13:21:53 1994
84	489	Donohue,J.	L	N/A	Wed Nov 02 13:21:53 1994
85	490	Fineburg,H.	R	N/A	Wed Nov 02 13:21:53 1994
86	491	Fineburg,H.	L	N/A	Wed Nov 02 13:21:53 1994
87	492	Costello, R.	R	N/A	Thu Nov 03 11:25:18 1994
88	493	Costello, R.	L	N/A	Thu Nov 03 11:25:18 1994
89	494	Ovdenko, D	R	N/A	Thu Nov 03 11:25:18 1994
90	495	Ovdenko, D	R	N/A	Thu Nov 03 11:25:18 1994
91	496	Chapek, J.	R	N/A	Tue Nov 08 17:35:09 1994
92	497	Chapek, J.	L	N/A	Tue Nov 08 17:35:09 1994
93	498	Ahrens, J.	R	N/A	Tue Nov 08 17:35:09 1994
94	499	Ahrens, J.	L	N/A	Tue Nov 08 17:35:09 1994
95	500	Peters, Jim	R	N/A	Wed Nov 09 12:03:36 1994
96	501	Peters, Jim	L	N/A	Wed Nov 09 12:04:21 1994
97	502	Nickell, Dan	R	N/A	Wed Nov 09 12:17:40 1994
98	503	Nickell, Dan	L	N/A	Wed Nov 09 12:18:35 1994
99	504	Gengler, Al	R	N/A	Thu Nov 10 09:14:11 1994
100	505	Gengler, Al	L	N/A	Thu Nov 10 09:14:11 1994
101	506	Weyers, K.	R	N/A	Fri Nov 11 11:31:22 1994
102	507	Weyers, K.	L	N/A	Fri Nov 11 11:31:22 1994
103	508	Williams, J.	R	N/A	Sat Nov 12 13:25:28 1994
104	509	Williams, J.	L	N/A	Sat Nov 12 13:25:28 1994
105	510	Wells, G.	R	N/A	Sat Nov 12 13:25:28 1994
106	511	Wells, G.	L	N/A	Sat Nov 12 13:25:28 1994
107	512	Caldwell. J.	R	N/A	Mon Nov 14 16:39:42 1994
108	513	Caldwell. J.	L	N/A	Mon Nov 14 16:39:42 1994
109	514	Vol #58	R	N/A	Tue Nov 15 13:34:38 1994
110	515	Vol #58	L	N/A	Tue Nov 15 13:34:38 1994
111	516	Vol #59	R	N/A	Tue Nov 15 13:34:38 1994
112	517	Vol #59	L	N/A	Tue Nov 15 13:34:38 1994
113	518	Vol #60	L	N/A	Tue Nov 15 13:40:38 1994
114	519	Vol #61	R	N/A	Tue Nov 15 13:40:38 1994
115	520	Vol #61	L	N/A	Tue Nov 15 13:40:38 1994
116	521	Vol #62	R	N/A	Tue Nov 15 13:40:38 1994
117	522	Vol #62 L	L	N/A	Tue Nov 15 13:40:38 1994
118	523	Vol #63 R	R	N/A	Tue Nov 15 13:50:38 1994
119	524	Vol #65 R	R	N/A	Tue Nov 15 13:50:38 1994
120	525	Vol #65 L	L	N/A	Tue Nov 15 13:50:38 1994

121	526	Vol #66 L	L	N/A	Tue Nov 15 13:50:38 1994
122	527	Vol #67 R	R	N/A	Tue Nov 15 13:50:38 1994
123	528	Vol #67 L	L	N/A	Tue Nov 15 13:50:38 1994
124	529	Vol #68 R	R	N/A	Tue Nov 15 14:34:38 1994
125	530	Vol #70 R	R	N/A	Tue Nov 15 14:34:38 1994
126	531	Vol #70 L	L	N/A	Tue Nov 15 14:34:38 1994
127	532	Vol #72 R	R	N/A	Tue Nov 15 14:34:38 1994
128	533	Vol #72 L	L	N/A	Tue Nov 15 14:34:38 1994
129	534	Vol #73 R	R	N/A	Tue Nov 15 14:34:38 1994
130	535	Vol #73 L	L	N/A	Tue Nov 15 14:34:38 1994
131	536	Vol #74 R	R	N/A	Tue Nov 15 14:34:38 1994
132	537	Vol #75 R	R	N/A	Tue Nov 15 15:34:38 1994
133	538	Vol #75 L	L	N/A	Tue Nov 15 15:34:38 1994
134	539	Vol #76 R	R	N/A	Tue Nov 15 15:34:38 1994
135	540	Vol #76 L	L	N/A	Tue Nov 15 15:34:38 1994
136	541	Vol #77 R	R	N/A	Tue Nov 15 15:34:38 1994
137	542	Vol #77 L	L	N/A	Tue Nov 15 15:34:38 1994
138	543	Vol #78 R	R	N/A	Tue Nov 15 15:34:38 1994
139	544	Vol #80 R	R	N/A	Tue Nov 15 15:34:38 1994
140	545	Vol #80 L	L	N/A	Tue Nov 15 15:34:38 1994
141	546	Vol #81 R	R	N/A	Tue Nov 15 15:34:38 1994
142	547	Vol #81 L	L	N/A	Tue Nov 15 15:34:38 1994
143	548	Vol #82 R	R	N/A	Tue Nov 15 15:34:38 1994
144	549	Vol #82 L	L	N/A	Tue Nov 15 15:34:38 1994
145	550	Vol #83 R	R	N/A	Tue Nov 15 16:00:38 1994
146	551	Vol #83 L	L	N/A	Tue Nov 15 16:00:38 1994
147	552	Vol #85 R	R	N/A	Tue Nov 15 16:00:38 1994
148	553	Vol #85 L	L	N/A	Tue Nov 15 16:00:38 1994
149	554	Vol #86 R	R	N/A	Tue Nov 15 16:00:38 1994
150	555	Vol #86 L	L	N/A	Tue Nov 15 16:00:38 1994
151	556	Vol #87 R	R	N/A	Tue Nov 15 16:00:38 1994
152	557	Vol #87 L	L	N/A	Tue Nov 15 16:00:38 1994
153	558	Vol #88 R	R	N/A	Tue Nov 15 16:34:38 1994
154	559	Vol #88 L	L	N/A	Tue Nov 15 16:34:38 1994
155	560	Vol #89 R	R	N/A	Tue Nov 15 16:34:38 1994
156	561	Vol #89 L	L	N/A	Tue Nov 15 16:34:38 1994
157	562	Vol #90 R	R	N/A	Tue Nov 15 16:34:38 1994
158	563	Vol #90 L	L	N/A	Tue Nov 15 16:34:38 1994
159	564	Vol #92 R	R	N/A	Tue Nov 15 16:34:38 1994
160	565	Vol #92 L	L	N/A	Tue Nov 15 16:34:38 1994

ANNEX 6

APPENDIX F

IDENTIFICATIONS FILE

19-DEC-94 OCTOBER 21...NOVEMBER 16, 1994

TRIAL #	FILE #	HD	# BITS COMP	# BITS DISAGREE	ROT	TIME	AVG TIME	NO. OF FILES	N-1	CUM COMP
1	406	0.043	1257	54	0	1.3	1.30	407	406	406
2	407	0.113	1244	141	0	1.2	1.25	407	406	812
3	406	0.099	1237	122	0	1.2	1.23	407	406	1,218
4	406	0.068	1263	86	0	1.2	1.23	407	406	1,624
5	406	0.033	1273	42	0	1.2	1.22	407	406	2,030
6	406	0.062	1278	79	0	1.3	1.23	407	406	2,436
7	407	0.133	1227	163	0	1.2	1.23	407	406	2,842
8	407	0.141	1230	173	0	1.2	1.23	407	406	3,248
9	407	0.158	1230	194	0	1.3	1.23	407	406	3,654
10	407	0.181	1205	218	0	1.3	1.24	407	406	4,060
11	406	0.043	1247	54	1.4	6.9	1.75	407	406	4,466
12	406	0.083	1240	103	0	1.1	1.70	407	406	4,872
13	406	0.108	1235	133	1.4	1.1	1.65	407	406	5,278
14	406	0.052	1232	64	1.4	1.1	1.61	407	406	5,684
15	406	0.047	1269	60	0	1.2	1.59	407	406	6,090
16	407	0.103	1226	126	0	1.1	1.56	407	406	6,496
17	407	0.158	1185	187	-1.4	1.1	1.53	407	406	6,902
18	407	0.181	1200	217	-1.4	1.1	1.51	407	406	7,308
19	407	0.167	1189	198	-1.4	1.1	1.48	407	406	7,714
20	407	0.106	1238	131	-1.4	1.1	1.47	407	406	8,120
21	406	0.246	1193	293	0	17.7	2.24	407	406	8,526
22	406	0.239	1179	282	1.4	11.9	2.68	407	406	8,932
23	406	0.068	1229	83	2.8	2.5	2.67	407	406	9,338
24	250	0.229	998	229	1.4	9.1	2.94	407	406	9,744
25	250	0.140	1084	152	0	5.1	3.02	407	406	10,150
26	250	0.165	1029	170	2.8	6.6	3.16	407	406	10,556
27	250	0.157	1054	165	1.4	1.2	3.09	407	406	10,962
28	250	0.155	1043	162	1.4	1.2	3.02	407	406	11,368
29	250	0.198	1056	209	1.4	1.2	2.96	407	406	11,774
30	250	0.206	1034	213	1.4	1.2	2.90	407	406	12,180
31	249	0.179	905	162	5.6	1.9	2.87	407	406	12,586
32	249	0.235	889	209	4.2	2.5	2.86	407	406	12,992
33	249	0.179	916	164	2.8	2.6	2.85	407	406	13,398
34	249	0.188	929	175	1.4	2.4	2.84	407	406	13,804
35	249	0.186	908	169	1.4	1.2	2.79	407	406	14,210
36	406	0.157	1192	187	1.4	5.3	2.86	407	406	14,616
37	406	0.151	1178	178	2.8	6.7	2.96	407	406	15,022
38	406	0.155	1209	187	2.8	1.3	2.92	407	406	15,428
39	406	0.163	1201	196	2.8	1.2	2.87	407	406	15,834
40	408	0.087	1220	106	0	1.3	2.84	409	408	16,242
41	408	0.242	1147	278	1.4	1.3	2.80	409	408	16,650
42	408	0.189	1194	226	0	1.2	2.76	409	408	17,058
43	408	0.270	1183	319	0	1.2	2.72	409	408	17,466
44	408	0.254	1186	301	0	1.1	2.69	409	408	17,874
45	409	0.124	1242	154	-1.4	1.2	2.65	409	408	18,282
46	409	0.118	1233	146	-1.4	1.2	2.62	409	408	18,690
47	409	0.106	1256	133	-1.4	1.2	2.59	409	408	19,098
48	409	0.145	1221	177	-2.8	1.2	2.56	409	408	19,506
49	409	0.087	1246	109	-1.4	1.2	2.53	409	408	19,914
50	410	0.163	1194	195	0	1.3	2.51	411	410	20,324
51	410	0.097	1232	120	0	1.3	2.49	411	410	20,734
52	410	0.119	1223	145	0	1.3	2.46	411	410	21,144
53	410	0.109	1217	133	-1.4	1.2	2.44	411	410	21,554
54	410	0.116	1218	141	-1.4	1.2	2.42	411	410	21,964
55	411	0.133	1205	160	-1.4	1.2	2.39	411	410	22,374
56	411	0.224	1190	266	-1.4	2.5	2.40	411	410	22,784
57	411	0.146	1222	178	-1.4	1.3	2.38	411	410	23,194
58	411	0.087	1228	107	0	2.5	2.38	411	410	23,604
59	411	0.131	1201	157	-1.4	1.3	2.36	411	410	24,014
60	412	0.226	1159	262	-1.4	2.5	2.36	413	412	24,426
61	412	0.259	1178	305	0	9.7	2.48	413	412	24,838
62	412	0.238	1157	275	-1.4	1.2	2.46	413	412	25,250
63	412	0.185	1196	221	0	1.1	2.44	413	412	25,662
64	412	0.258	1160	299	0	1.1	2.42	413	412	26,074
65	412	0.258	1181	305	0	7.6	2.50	413	412	26,486

66	413	0.257	1200	308	-1.4	5.7	2.55	413	412	26,898
67	413	0.277	1168	323	-1.4	1.3	2.53	413	412	27,310
68	413	0.262	1200	315	0	7.7	2.61	413	412	27,722
69	413	0.247	1229	304	0	3.8	2.62	413	412	28,134
70	413	0.283	1210	343	0	3.8	2.64	413	412	28,546
71	415	0.094	1220	115	0	1.3	2.62	416	415	28,961
72	415	0.123	1235	152	0	1.3	2.60	416	415	29,376
73	415	0.120	1227	147	0	1.3	2.58	416	415	29,791
74	415	0.118	1241	147	0	1.3	2.57	416	415	30,206
75	415	0.147	1224	180	0	1.3	2.55	416	415	30,621
76	416	0.276	1130	312	7	3.8	2.57	416	415	31,036
77	416	0.230	1098	252	7	7.2	2.63	416	415	31,451
78	416	0.218	1175	256	7	8.7	2.71	416	415	31,866
79	416	0.265	1149	305	7	1.2	2.69	416	415	32,281
80	416	0.212	1167	247	7	1.2	2.67	416	415	32,696
81	415	0.241	1179	284	-2.8	3.2	2.67	416	415	33,111
82	416	0.165	1162	192	5.6	1.3	2.66	416	415	33,526
83	406	0.175	1210	212	0	1.2	2.64	416	415	33,941
84	406	0.175	1226	215	0	1.2	2.62	416	415	34,356
85	406	0.166	1219	202	0	1.2	2.61	416	415	34,771
86	406	0.241	1198	289	0	1.3	2.59	416	415	35,186
87	406	0.174	1207	210	0	1.2	2.57	416	415	35,601
88	406	0.174	1210	210	0	1.2	2.56	416	415	36,016
89	407	0.203	1180	240	-1.4	2.5	2.56	416	415	36,431
90	407	0.194	1195	232	-1.4	1.3	2.54	416	415	36,846
91	407	0.176	1190	210	-1.4	1.2	2.53	416	415	37,261
92	407	0.237	1207	286	-1.4	1.2	2.52	416	415	37,676
93	407	0.265	1200	318	-1.4	1.3	2.50	416	415	38,091
94	408	0.270	1071	289	-2.8	5.0	2.53	416	415	38,506
95	409	0.227	1188	270	-2.8	2.5	2.53	416	415	38,921
96	408	0.151	1169	177	-2.8	1.2	2.51	416	415	39,336
97	415	0.274	1168	320	0	1.9	2.51	416	415	39,751
98	415	0.267	1167	312	2.8	2.6	2.51	416	415	40,166
99	415	0.248	1141	283	4.2	1.3	2.50	416	415	40,581
100	415	0.225	1162	262	4.2	2.6	2.50	416	415	40,996
101	415	0.247	1170	289	2.8	1.3	2.49	416	415	41,411
102	416	0.197	1194	235	2.8	3.2	2.49	416	415	41,826
103	416	0.151	1225	185	1.4	5.1	2.52	416	415	42,241
104	416	0.114	1241	141	0	5.8	2.55	416	415	42,656
105	416	0.148	1234	183	-1.4	5.2	2.58	416	415	43,071
106	408	0.066	1258	83	-1.4	3.1	2.58	416	415	43,486
107	408	0.134	1206	162	-1.4	1.3	2.57	416	415	43,901
108	408	0.108	1215	131	-2.8	1.2	2.56	416	415	44,316
109	408	0.132	1216	161	-2.8	1.2	2.54	416	415	44,731
110	408	0.113	1230	139	-1.4	1.2	2.53	416	415	45,146
111	409	0.089	1234	110	-1.4	2.5	2.53	416	415	45,561
112	409	0.185	1221	226	-1.4	2.5	2.53	416	415	45,976
113	409	0.146	1203	176	-2.8	1.2	2.52	416	415	46,391
114	409	0.102	1212	124	-2.8	1.2	2.51	416	415	46,806
115	409	0.223	1190	265	-2.8	1.3	2.50	416	415	47,221
116	410	0.173	1208	209	-1.4	5.5	2.52	416	415	47,636
117	410	0.124	1204	149	-1.4	1.3	2.51	416	415	48,051
118	410	0.131	1218	160	-1.4	1.3	2.50	416	415	48,466
119	410	0.217	1187	257	0	2.6	2.50	416	415	48,881
120	410	0.160	1212	194	0	1.2	2.49	416	415	49,296
121	410	0.138	1218	168	-1.4	1.2	2.48	416	415	49,711
122	411	0.192	1177	226	-2.8	2.5	2.48	416	415	50,126
123	411	0.264	1181	312	-2.8	1.2	2.47	416	415	50,541
124	411	0.206	1194	246	-2.8	2.6	2.47	416	415	50,956
125	411	0.152	1207	183	-4.2	2.5	2.47	416	415	51,371
126	411	0.153	1192	182	-4.2	6.5	2.50	416	415	51,786
127	412	0.188	1165	219	0	2.5	2.50	416	415	52,201
128	412	0.202	1185	239	0	1.1	2.49	416	415	52,616
129	412	0.180	1176	212	0	1.1	2.48	416	415	53,031
130	412	0.199	1170	233	0	1.1	2.47	416	415	53,446
131	412	0.204	1167	238	0	1.1	2.46	416	415	53,861
132	413	0.184	1199	221	0	2.6	2.46	416	415	54,276
133	413	0.172	1189	204	0	1.2	2.45	416	415	54,691
134	413	0.259	1149	298	1.4	1.2	2.44	416	415	55,106
135	413	0.235	1179	277	1.4	1.1	2.43	416	415	55,521
136	413	0.229	1168	268	1.4	1.1	2.42	416	415	55,936
137	250	0.201	1072	215	0	12.7	2.50	416	415	56,351
138	250	0.148	1080	160	-1.4	1.2	2.49	416	415	56,766
139	250	0.146	1072	157	-1.4	1.2	2.48	416	415	57,181
140	250	0.224	1071	240	-1.4	1.1	2.47	416	415	57,596

141	250	0.209	1062	222	-2.8	1.2	2.46	416	415	58,011
142	250	0.180	1063	191	-2.8	1.2	2.45	416	415	58,426
143	249	0.185	896	166	4.2	3.9	2.46	416	415	58,841
144	249	0.221	892	197	2.8	2.5	2.46	416	415	59,256
145	249	0.180	895	161	2.8	1.2	2.45	416	415	59,671
146	249	0.202	892	180	1.4	1.2	2.45	416	415	60,086
147	249	0.183	913	167	1.4	1.2	2.44	416	415	60,501
148	406	0.215	1183	254	0	1.2	2.43	416	415	60,916
149	406	0.070	1233	86	0	1.2	2.42	416	415	61,331
150	406	0.090	1232	111	0	1.2	2.41	416	415	61,746
151	406	0.065	1234	80	0	1.3	2.40	416	415	62,161
152	406	0.081	1239	100	1.4	1.2	2.40	416	415	62,576
153	406	0.076	1217	92	1.4	1.2	2.39	416	415	62,991
154	406	0.090	1240	111	0	1.2	2.38	416	415	63,406
155	407	0.157	1225	192	-1.4	1.2	2.37	416	415	63,821
156	407	0.128	1247	159	-1.4	1.2	2.37	416	415	64,236
157	407	0.210	1202	252	-1.4	1.2	2.36	416	415	64,651
158	407	0.142	1229	174	-1.4	1.2	2.35	416	415	65,066
159	407	0.187	1195	223	-1.4	1.2	2.34	416	415	65,481
160	407	0.150	1203	181	-2.8	1.3	2.34	416	415	65,896
161	407	0.130	1201	156	-1.4	1.2	2.33	416	415	66,311
162	406	0.073	1226	89	1.4	1.2	2.32	416	415	66,726
163	406	0.069	1234	85	2.8	1.2	2.32	416	415	67,141
164	406	0.134	1196	160	1.4	1.2	2.31	416	415	67,556
165	406	0.214	1167	250	1.4	1.1	2.30	416	415	67,971
166	406	0.060	1240	75	1.4	1.2	2.30	416	415	68,386
167	406	0.066	1224	81	2.8	1.1	2.29	416	415	68,801
168	406	0.153	1199	184	1.4	1.2	2.28	416	415	69,216
169	406	0.191	1156	221	2.8	1.3	2.28	416	415	69,631
170	406	0.093	1206	112	1.4	1.2	2.27	416	415	70,046
171	406	0.215	1194	257	1.4	1.2	2.26	416	415	70,461
172	406	0.176	1190	210	1.4	31.3	2.43	416	415	70,876
173	417	0.154	1231	190	0	5.9	2.45	418	417	71,293
174	417	0.223	1199	267	0	1.3	2.45	418	417	71,710
175	417	0.157	1207	190	0	1.2	2.44	418	417	72,127
176	417	0.141	1210	171	0	1.2	2.43	418	417	72,544
177	417	0.211	1148	242	0	1.2	2.42	418	417	72,961
178	417	0.231	1166	269	0	1.2	2.42	418	417	73,378
179	418	0.169	1140	193	2.8	1.3	2.41	418	417	73,795
180	418	0.160	1166	186	2.8	1.2	2.41	418	417	74,212
181	418	0.131	1179	154	2.8	2.5	2.41	418	417	74,629
182	418	0.166	1150	191	2.8	1.1	2.40	418	417	75,046
183	418	0.165	1136	188	2.8	1.3	2.39	418	417	75,463
184	418	0.199	1164	232	2.8	1.2	2.39	418	417	75,880
185	417	0.203	1190	241	0	13.8	2.45	418	417	76,297
186	417	0.212	1173	249	0	7.2	2.47	418	417	76,714
187	417	0.220	1202	264	0	5.3	2.49	418	417	77,131
188	417	0.142	1200	171	1.4	5.1	2.50	418	417	77,548
189	417	0.212	1197	254	-1.4	3.2	2.51	418	417	77,965
190	417	0.173	1194	207	1.4	3.2	2.51	418	417	78,382
191	417	0.204	1178	240	1.4	3.1	2.51	418	417	78,799
192	417	0.161	1201	193	1.4	5.2	2.53	418	417	79,216
193	415	0.257	1173	301	0	7.0	2.55	418	417	79,633
194	417	0.240	1213	291	0	5.8	2.57	418	417	80,050
195	417	0.172	1212	208	0	5.9	2.58	418	417	80,467
196	418	0.174	1162	202	1.4	7.8	2.61	418	417	80,884
197	417	0.230	1203	277	-1.4	17.1	2.68	418	417	81,301
198	417	0.280	1188	333	-1.4	4.6	2.69	418	417	81,718
199	406	0.188	1184	223	1.4	5.4	2.71	418	417	82,135
200	406	0.118	1190	141	1.4	3.9	2.71	418	417	82,552
201	406	0.273	1159	316	1.4	4.6	2.72	418	417	82,969
202	406	0.180	1142	206	1.4	7.2	2.74	418	417	83,386
203	406	0.187	1181	221	1.4	4.5	2.75	418	417	83,803
204	406	0.241	1163	280	1.4	10.5	2.79	418	417	84,220
205	406	0.212	1191	253	0	3.7	2.80	418	417	84,637
206	406	0.228	1147	262	2.8	6.7	2.81	418	417	85,054
207	406	0.172	1191	205	1.4	3.3	2.82	418	417	85,471
208	406	0.171	1192	204	1.4	1.2	2.81	418	417	85,888
209	406	0.147	1170	172	1.4	2.5	2.81	418	417	86,305
210	406	0.234	1200	281	0	2.5	2.81	418	417	86,722
211	406	0.150	1177	177	0	1.9	2.80	418	417	87,139
212	406	0.227	1180	268	0	20.4	2.88	418	417	87,556
213	415	0.237	1182	280	0	0.0	2.87	418	417	87,973
214	415	0.193	1176	227	-2.8	2.6	2.87	418	417	88,390
215	417	0.242	1178	285	1.4	3.3	2.87	418	417	88,807

216	417	0.220	1210	266	0	2.5	2.87	418	417	89,224
217	417	0.188	1182	222	-1.4	1.2	2.86	418	417	89,641
218	417	0.135	1219	165	-1.4	1.3	2.86	418	417	90,058
219	417	0.177	1200	213	2.8	3.2	2.86	418	417	90,475
220	417	0.242	1174	284	0	5.2	2.87	418	417	90,892
221	417	0.203	1198	243	0	1.2	2.86	418	417	91,309
222	417	0.223	1194	266	0	1.2	2.85	418	417	91,726
223	417	0.229	1164	266	0	2.5	2.85	418	417	92,143
224	417	0.158	1163	184	0	2.6	2.85	418	417	92,560
225	418	0.177	1134	201	4.2	1.2	2.84	418	417	92,977
226	417	0.128	1206	154	0	1.2	2.84	418	417	93,394
227	417	0.213	1163	248	1.4	4.0	2.84	418	417	93,811
228	417	0.201	1132	228	1.4	5.1	2.85	418	417	94,228
229	417	0.152	1201	182	0	8.5	2.88	418	417	94,645
230	417	0.194	1201	233	0	1.2	2.87	418	417	95,062
231	417	0.164	1218	200	0	2.5	2.87	418	417	95,479
232	417	0.175	1203	210	0	2.6	2.87	418	417	95,896
233	417	0.207	1156	239	1.4	1.2	2.86	418	417	96,313
234	417	0.196	1203	236	0	3.1	2.86	418	417	96,730
235	417	0.181	1201	217	0	1.2	2.85	418	417	97,147
236	406	0.215	1153	248	2.8	3.2	2.85	418	417	97,564
237	406	0.223	1125	251	1.4	2.5	2.85	418	417	97,981
238	406	0.210	1135	238	1.4	1.1	2.84	418	417	98,398
239	406	0.100	1222	122	0	1.2	2.84	418	417	98,815
240	406	0.143	1177	168	0	1.2	2.83	418	417	99,232
241	406	0.093	1219	113	0	1.2	2.82	418	417	99,649
242	406	0.110	1208	133	1.4	1.3	2.82	418	417	100,066
243	406	0.114	1220	139	0	1.2	2.81	418	417	100,483
244	406	0.168	1186	199	1.4	1.1	2.80	418	417	100,900
245	406	0.212	1199	254	0	1.3	2.80	418	417	101,317
246	406	0.120	1220	147	1.4	1.1	2.79	418	417	101,734
247	406	0.167	1182	197	1.4	1.2	2.78	418	417	102,151
248	415	0.224	1182	265	-2.8	1.2	2.78	418	417	102,568
249	415	0.212	1219	259	-1.4	5.9	2.79	418	417	102,985
250	417	0.169	1220	206	0	3.8	2.79	418	417	103,402
251	417	0.274	1094	300	2.8	1.4	2.79	418	417	103,819
252	417	0.223	1158	258	2.8	6.0	2.80	418	417	104,236
253	417	0.184	1211	223	0	4.5	2.81	418	417	104,653
254	417	0.213	1193	254	0	3.8	2.81	418	417	105,070
255	417	0.223	1180	263	1.4	5.2	2.82	418	417	105,487
256	415	0.225	1177	265	-2.8	7.8	2.84	418	417	105,904
257	415	0.206	1201	247	-1.4	1.3	2.84	418	417	106,321
258	415	0.196	1195	234	-4.2	1.2	2.83	418	417	106,738
259	415	0.185	1224	227	-2.8	1.2	2.82	418	417	107,155
260	415	0.241	1181	285	-2.8	2.5	2.82	418	417	107,572
261	415	0.219	1202	263	-2.8	1.2	2.82	418	417	107,989
262	407	0.231	1167	270	5.6	1.2	2.81	418	417	108,406
263	407	0.181	1190	215	5.6	1.2	2.80	418	417	108,823
264	407	0.161	1175	189	5.6	1.2	2.80	418	417	109,240
265	407	0.153	1187	182	5.6	1.1	2.79	418	417	109,657
266	407	0.187	1171	219	5.6	1.2	2.78	418	417	110,074
267	417	0.174	1154	201	5.6	3.2	2.79	418	417	110,491
268	417	0.281	1176	331	2.8	7.1	2.80	418	417	110,908
269	417	0.147	1151	169	1.4	5.2	2.81	418	417	111,325
270	419	0.186	1212	226	0	5.3	2.82	420	419	111,744
271	420	0.239	1160	277	1.4	1.9	2.82	420	419	112,163
272	417	0.204	1139	232	1.4	4.6	2.82	420	419	112,582
273	415	0.193	1204	232	0	4.0	2.83	420	419	113,001
274	415	0.243	1172	285	0	1.9	2.82	420	419	113,420
275	419	0.265	1198	318	-1.4	4.0	2.83	420	419	113,839
276	406	0.135	1212	164	1.4	1.2	2.82	420	419	114,258
277	421	0.119	1168	139	1.4	1.3	2.82	421	420	114,678
278	417	0.188	1169	220	-1.4	5.8	2.83	421	420	115,098
279	417	0.179	1210	216	-1.4	6.6	2.84	421	420	115,518
280	415	0.219	1208	265	1.4	6.7	2.86	421	420	115,938
281	406	0.200	1197	239	0	5.2	2.86	421	420	116,358
282	406	0.210	1132	238	1.4	1.2	2.86	421	420	116,778
283	406	0.152	1140	173	1.4	1.2	2.85	421	420	117,198
284	406	0.224	1155	259	1.4	1.2	2.85	421	420	117,618
285	406	0.185	1164	215	1.4	1.2	2.84	421	420	118,038
286	415	0.270	1172	316	-1.4	3.9	2.84	421	420	118,458
287	415	0.228	1207	275	-1.4	4.5	2.85	421	420	118,878
288	415	0.266	1180	314	-1.4	1.3	2.84	421	420	119,298
289	415	0.251	1169	293	-1.4	1.2	2.84	421	420	119,718
290	415	0.276	1171	323	-1.4	1.3	2.83	421	420	120,138

291	415	0.227	1194	271	-1.4	1.2	2.83	421	420	120,558
292	415	0.267	1172	313	-1.4	1.3	2.82	421	420	120,978
293	415	0.238	1185	282	-1.4	1.2	2.82	421	420	121,398
294	415	0.250	1177	294	-1.4	2.6	2.82	421	420	121,818
295	415	0.228	1196	273	-1.4	2.6	2.82	421	420	122,238
296	415	0.229	1190	272	-1.4	1.2	2.81	421	420	122,658
297	415	0.275	1160	319	-1.4	2.6	2.81	421	420	123,078
298	415	0.261	1174	307	0	1.2	2.80	421	420	123,498
299	415	0.258	1174	303	0	1.2	2.80	421	420	123,918
300	415	0.271	1184	321	-1.4	1.2	2.79	421	420	124,338
301	415	0.195	1199	234	0	2.6	2.79	421	420	124,758
302	415	0.236	1202	284	0	2.6	2.79	421	420	125,178
303	415	0.229	1184	271	0	1.2	2.79	421	420	125,598
304	415	0.219	1201	263	0	1.1	2.78	421	420	126,018
305	417	0.238	1196	285	-1.4	5.9	2.79	421	420	126,438
306	417	0.163	1165	190	-1.4	2.5	2.79	421	420	126,858
307	417	0.131	1195	156	-1.4	1.2	2.79	421	420	127,278
308	417	0.177	1211	214	-1.4	1.2	2.78	421	420	127,698
309	417	0.164	1216	200	-1.4	1.2	2.78	421	420	128,118
310	418	0.158	1174	185	1.4	2.5	2.77	421	420	128,538
311	418	0.129	1205	155	1.4	1.3	2.77	421	420	128,958
312	418	0.119	1189	142	1.4	1.3	2.76	421	420	129,378
313	418	0.134	1190	159	1.4	1.2	2.76	421	420	129,798
314	418	0.118	1201	142	1.4	1.3	2.76	421	420	130,218
315	406	0.178	1214	216	-1.4	8.5	2.77	421	420	130,638
316	406	0.108	1173	127	1.4	1.2	2.77	421	420	131,058
317	406	0.119	1190	142	2.8	1.2	2.76	421	420	131,478
318	406	0.187	1161	217	1.4	1.3	2.76	421	420	131,898
319	406	0.081	1201	97	1.4	1.3	2.75	421	420	132,318
320	406	0.096	1190	114	1.4	1.2	2.75	421	420	132,738
321	406	0.111	1172	130	1.4	1.2	2.74	421	420	133,158
322	422	0.147	1207	178	2.8	6.0	2.75	423	422	133,580
323	415	0.236	1176	277	0	1.3	2.75	423	422	134,002
324	423	0.190	1194	227	-1.4	5.9	2.76	423	422	134,424
325	417	0.176	1183	208	1.4	1.9	2.76	423	422	134,846
326	417	0.200	1189	238	2.8	1.2	2.75	423	422	135,268
327	417	0.230	1185	272	2.8	1.2	2.75	423	422	135,690
328	417	0.269	1080	290	1.4	1.3	2.74	423	422	136,112
329	417	0.250	1159	290	0	2.0	2.74	423	422	136,534
330	417	0.149	1216	181	-1.4	4.6	2.75	423	422	136,956
331	415	0.233	1204	281	0	1.2	2.74	423	422	137,378
332	406	0.154	1146	177	1.4	3.9	2.75	423	422	137,800
333	406	0.156	1144	178	0	1.2	2.74	423	422	138,222
334	415	0.239	1188	284	0	1.3	2.74	423	422	138,644
335	406	0.207	1167	242	1.4	6.8	2.75	423	422	139,066
336	425	0.257	1151	296	4.2	8.5	2.77	423	422	139,488
337	417	0.186	1198	223	0	5.9	2.78	423	422	139,910
338	415	0.254	1169	297	-1.4	2.6	2.77	423	422	140,332
339	406	0.189	1172	221	1.4	5.1	2.78	423	422	140,754
340	415	0.264	1180	312	1.4	3.2	2.78	423	422	141,176
341	415	0.227	1197	272	-1.4	4.1	2.79	423	422	141,598
342	417	0.200	1188	238	-1.4	4.6	2.79	423	422	142,020
343	415	0.207	1173	243	2.8	1.3	2.79	423	422	142,442
344	415	0.244	1210	295	0	1.3	2.78	423	422	142,864
345	426	0.143	1178	168	1.4	2.8	2.78	427	426	143,290
346	415	0.243	1196	291	0	1.9	2.78	427	426	143,716
347	417	0.204	1142	233	-1.4	4.8	2.79	427	426	144,142
348	406	0.182	1195	218	2.8	4.8	2.79	427	426	144,568
349	406	0.241	1181	285	1.4	4.7	2.80	427	426	144,994
350	406	0.056	1248	70	1.4	5.9	2.81	427	426	145,420
351	417	0.203	1136	231	1.4	7.4	2.82	427	426	145,846
352	417	0.160	1199	192	-4.2	5.2	2.83	427	426	146,272
353	415	0.194	1200	233	0	2.6	2.83	427	426	146,698
354	406	0.074	1222	91	2.8	1.3	2.82	427	426	147,124
355	422	0.150	1221	183	2.8	3.9	2.82	427	426	147,550
356	415	0.211	1206	255	-1.4	2.6	2.82	427	426	147,976
357	415	0.250	1201	300	0	1.2	2.82	427	426	148,402
358	415	0.188	1198	225	0	2.0	2.82	427	426	148,828
359	428	0.276	1184	327	0	13.4	2.85	429	428	149,256
360	429	0.257	1181	304	-2.8	2.6	2.85	429	428	149,684
361	415	0.239	1200	287	0	4.0	2.85	429	428	150,112
362	417	0.244	1195	291	0	7.3	2.86	429	428	150,540
363	418	0.272	1156	314	0	3.2	2.86	429	428	150,968
364	418	0.163	1196	195	0	3.8	2.86	429	428	151,396
365	418	0.155	1168	181	1.4	4.6	2.87	429	428	151,824

366	418	0.202	1164	235	1.4	5.9	2.88	429	428	152,252
367	418	0.203	1135	230	2.8	3.8	2.88	429	428	152,680
368	418	0.218	1104	241	4.2	1.9	2.88	429	428	153,108
369	417	0.201	1160	233	1.4	4.6	2.88	429	428	153,536
370	417	0.270	1176	318	-1.4	12.6	2.91	429	428	153,964
371	417	0.280	1161	325	-2.8	7.4	2.92	429	428	154,392
372	415	0.180	1199	216	2.8	6.0	2.93	429	428	154,820
373	415	0.217	1189	258	1.4	1.3	2.92	429	428	155,248
374	415	0.209	1190	249	-1.4	5.3	2.93	429	428	155,676
375	415	0.236	1188	280	-1.4	1.3	2.93	429	428	156,104
376	406	0.074	1225	91	1.4	1.9	2.92	429	428	156,532
377	415	0.246	1202	296	-1.4	1.9	2.92	429	428	156,960
378	430	0.167	1248	209	1.4	5.2	2.93	431	430	157,390
379	406	0.224	1156	259	1.4	4.7	2.93	431	430	157,820
380	426	0.105	1221	128	0	5.4	2.94	431	430	158,250
381	432	0.215	1193	257	1.4	14.6	2.97	433	432	158,682
382	406	0.089	1217	108	1.4	5.9	2.98	433	432	159,114
383	406	0.137	1195	164	0	8.0	2.99	433	432	159,546
384	406	0.220	1166	256	1.4	7.3	3.00	433	432	159,978
385	406	0.139	1202	167	0	4.5	3.00	433	432	160,410
386	406	0.229	1175	269	1.4	1.3	3.00	433	432	160,842
387	434	0.234	1173	275	1.4	13.4	3.03	434	433	161,275
388	406	0.123	1211	149	0	1.9	3.02	434	433	161,708
389	417	0.173	1153	199	-1.4	4.6	3.03	434	433	162,141
390	417	0.276	1162	321	-2.8	3.9	3.03	434	433	162,574
391	417	0.245	1133	278	1.4	7.1	3.04	434	433	163,007
392	417	0.247	1140	282	0	2.5	3.04	434	433	163,440
393	417	0.205	1126	231	0	1.2	3.04	434	433	163,873
394	417	0.193	1155	223	-1.4	6.4	3.04	434	433	164,306
395	406	0.276	1166	322	2.8	1.2	3.04	434	433	164,739
396	406	0.263	1162	306	1.4	1.4	3.03	434	433	165,172
397	406	0.096	1223	117	0	1.2	3.03	434	433	165,605
398	406	0.076	1224	93	1.4	1.2	3.03	434	433	166,038
399	417	0.187	1196	224	-4.2	5.9	3.03	434	433	166,471
400	406	0.274	1155	317	2.8	2.5	3.03	434	433	166,904
401	406	0.098	1208	118	1.4	2.6	3.03	434	433	167,337
402	406	0.137	1210	166	1.4	3.8	3.03	434	433	167,770
403	406	0.156	1183	185	1.4	6.8	3.04	434	433	168,203
404	436	0.068	1253	85	-2.8	8.7	3.06	436	435	168,638
405	406	0.211	1179	249	2.8	1.9	3.05	436	435	169,073
406	407	0.207	1189	246	2.8	7.9	3.06	436	435	169,508
407	406	0.094	1215	114	1.4	3.9	3.07	436	435	169,943
408	406	0.068	1230	84	1.4	9.8	3.08	436	435	170,378
409	406	0.198	1177	233	1.4	1.2	3.08	436	435	170,813
410	415	0.242	1171	283	-7	1.4	3.07	436	435	171,248
411	415	0.265	1189	315	0	6.7	3.08	436	435	171,683
412	406	0.130	1206	157	1.4	12.7	3.11	436	435	172,118
413	437	0.229	1164	267	5.6	7.3	3.12	438	437	172,555
414	437	0.170	1176	200	5.6	11.8	3.14	438	437	172,992
415	438	0.166	1196	199	-1.4	7.8	3.15	438	437	173,429
416	415	0.267	1168	312	0	1.3	3.14	438	437	173,866
417	415	0.190	1218	232	0	1.3	3.14	438	437	174,303
418	439	0.269	1168	314	-1.4	8.1	3.15	440	439	174,742
419	417	0.228	1171	267	1.4	37.5	3.23	440	439	175,181
420	417	0.209	1175	246	-2.8	9.9	3.25	440	439	175,620
421	415	0.231	1180	273	1.4	1.3	3.25	440	439	176,059
422	415	0.256	1187	304	0	3.2	3.25	440	439	176,498
423	415	0.264	1160	306	1.4	1.2	3.24	440	439	176,937
424	415	0.222	1180	262	1.4	1.3	3.24	440	439	177,376
425	415	0.230	1163	268	1.4	1.3	3.23	440	439	177,815
426	415	0.217	1190	258	1.4	3.4	3.23	440	439	178,254
427	415	0.226	1194	270	2.8	17.3	3.26	440	439	178,693
428	415	0.212	1190	252	2.8	1.2	3.26	440	439	179,132
429	415	0.217	1186	257	1.4	4.0	3.26	440	439	179,571
430	415	0.197	1179	232	2.8	1.2	3.26	440	439	180,010
431	415	0.219	1180	258	2.8	2.6	3.26	440	439	180,449
432	415	0.210	1203	253	2.8	1.2	3.25	440	439	180,888
433	415	0.219	1186	260	2.8	1.3	3.25	440	439	181,327
434	415	0.216	1206	260	2.8	1.3	3.24	440	439	181,766
435	415	0.263	1183	311	2.8	1.2	3.24	440	439	182,205
436	415	0.180	1180	212	2.8	1.2	3.23	440	439	182,644
437	415	0.219	1189	260	2.8	1.2	3.23	440	439	183,083
438	415	0.260	1187	309	2.8	1.2	3.22	440	439	183,522
439	415	0.204	1184	242	2.8	1.1	3.22	440	439	183,961
440	406	0.180	1194	215	2.8	1.2	3.21	440	439	184,400

441	406	0.065	1237	81	1.4	1.2	3.21	440	439	184,839
442	406	0.071	1233	88	1.4	1.2	3.20	440	439	185,278
443	406	0.161	1195	192	1.4	1.2	3.20	440	439	185,717
444	406	0.161	1197	193	1.4	1.2	3.20	440	439	186,156
445	406	0.131	1227	161	1.4	1.2	3.19	440	439	186,595
446	406	0.085	1229	105	1.4	1.2	3.19	440	439	187,034
447	406	0.119	1223	145	1.4	1.3	3.18	440	439	187,473
448	406	0.082	1234	101	1.4	1.2	3.18	440	439	187,912
449	406	0.228	1170	267	1.4	1.2	3.17	440	439	188,351
450	406	0.086	1238	106	1.4	1.2	3.17	440	439	188,790
451	406	0.180	1174	211	1.4	1.2	3.16	440	439	189,229
452	406	0.190	1204	229	1.4	1.2	3.16	440	439	189,668
453	406	0.151	1194	180	1.4	2.5	3.16	440	439	190,107
454	406	0.151	1197	181	1.4	1.3	3.15	440	439	190,546
455	406	0.107	1189	127	0	1.2	3.15	440	439	190,985
456	406	0.073	1225	89	1.4	1.2	3.15	440	439	191,424
457	415	0.222	1196	265	0	1.2	3.14	440	439	191,863
458	417	0.141	1232	174	-1.4	13.8	3.17	440	439	192,302
459	417	0.229	1187	272	0	5.2	3.17	440	439	192,741
460	406	0.195	1161	226	1.4	11.8	3.19	440	439	193,180
461	406	0.233	1172	273	0	3.8	3.19	440	439	193,619
462	406	0.183	1208	221	0	5.3	3.19	440	439	194,058
463	406	0.188	1199	226	0	3.9	3.20	440	439	194,497
464	406	0.121	1218	147	1.4	13.2	3.22	440	439	194,936
465	406	0.141	1195	169	1.4	7.3	3.23	440	439	195,375
466	406	0.097	1208	117	0	7.3	3.23	440	439	195,814
467	442	0.229	1164	266	-1.4	6.7	3.24	443	442	196,256
468	442	0.254	1162	295	-1.4	2.6	3.24	443	442	196,698
469	441	0.245	1165	285	-4.2	5.1	3.24	443	442	197,140
470	441	0.133	1208	161	-2.8	1.2	3.24	443	442	197,582
471	442	0.097	1262	123	-1.4	1.3	3.24	443	442	198,024
472	441	0.246	1195	294	-2.8	2.5	3.23	443	442	198,466
473	443	0.237	1149	272	-1.4	3.8	3.24	443	442	198,908
474	443	0.199	1164	232	0	1.1	3.23	443	442	199,350
475	443	0.143	1172	168	-1.4	1.2	3.23	443	442	199,792
476	443	0.269	1137	306	-1.4	5.0	3.23	443	442	200,234
477	443	0.177	1167	206	0	1.2	3.23	443	442	200,676
478	443	0.149	1187	177	-1.4	3.8	3.23	443	442	201,118
479	406	0.194	1183	229	-1.4	6.2	3.23	443	442	201,560
480	406	0.206	1191	245	-1.4	7.3	3.24	443	442	202,002
481	406	0.230	1169	269	0	5.2	3.25	443	442	202,444
482	406	0.071	1231	87	1.4	4.6	3.25	443	442	202,886
483	406	0.068	1214	82	1.4	1.3	3.25	443	442	203,328
484	417	0.187	1238	231	-1.4	1.3	3.24	443	442	203,770
485	417	0.139	1220	169	-1.4	5.2	3.25	443	442	204,212
486	417	0.183	1144	209	0	1.2	3.24	443	442	204,654
487	417	0.193	1208	233	-1.4	3.9	3.24	443	442	205,096
488	417	0.212	1164	247	-1.4	1.2	3.24	443	442	205,538
489	417	0.228	1138	260	-1.4	2.5	3.24	443	442	205,980
490	417	0.156	1189	186	-2.8	1.2	3.23	443	442	206,422
491	417	0.148	1233	182	-1.4	1.2	3.23	443	442	206,864
492	415	0.152	1230	187	0	1.3	3.22	443	442	207,306
493	415	0.228	1185	270	-4.2	1.3	3.22	443	442	207,748
494	406	0.051	1230	63	1.4	1.2	3.22	443	442	208,190
495	406	0.049	1263	62	0	1.3	3.21	443	442	208,632
496	415	0.259	1226	317	-1.4	2.5	3.21	443	442	209,074
497	415	0.176	1211	213	-2.8	1.2	3.21	443	442	209,516
498	417	0.186	1166	217	-2.8	2.6	3.21	443	442	209,958
499	415	0.203	1211	246	-1.4	7.4	3.21	443	442	210,400
500	417	0.255	1190	304	-1.4	3.3	3.21	443	442	210,842
501	417	0.221	1173	259	-1.4	4.0	3.22	443	442	211,284
502	444	0.212	1090	231	-1.4	5.1	3.22	444	443	211,727
503	445	0.174	1158	201	0	1.2	3.22	446	445	212,172
504	445	0.238	1138	271	0	1.2	3.21	446	445	212,617
505	446	0.095	1181	112	0	1.2	3.21	446	445	213,062
506	447	0.097	1264	123	0	1.3	3.20	448	447	213,509
507	447	0.143	1235	176	0	1.3	3.20	448	447	213,956
508	447	0.079	1277	101	0	1.2	3.20	448	447	214,403
509	447	0.046	1279	59	0	1.2	3.19	448	447	214,850
510	447	0.078	1270	99	0	1.2	3.19	448	447	215,297
511	448	0.136	1193	162	1.4	1.3	3.18	448	447	215,744
512	448	0.046	1301	60	0	1.2	3.18	448	447	216,191
513	448	0.088	1254	110	0	1.2	3.18	448	447	216,638
514	448	0.037	1300	48	0	1.2	3.17	448	447	217,085
515	448	0.042	1297	54	0	1.2	3.17	448	447	217,532

516	448	0.124	1228	152	0	1.2	3.17	448	447	217,979
517	406	0.107	1209	129	1.4	3.4	3.17	448	447	218,426
518	449	0.197	1187	234	-1.4	3.9	3.17	450	449	218,875
519	449	0.113	1214	137	-1.4	1.3	3.16	450	449	219,324
520	449	0.096	1223	118	0	1.3	3.16	450	449	219,773
521	449	0.144	1213	175	0	1.3	3.16	450	449	220,222
522	449	0.125	1203	150	0	1.3	3.15	450	449	220,671
523	450	0.197	1185	233	-2.8	2.7	3.15	450	449	221,120
524	450	0.125	1219	152	0	7.3	3.16	450	449	221,569
525	450	0.106	1235	131	0	1.3	3.16	450	449	222,018
526	450	0.095	1227	116	0	1.3	3.15	450	449	222,467
527	450	0.132	1217	161	0	1.3	3.15	450	449	222,916
528	450	0.237	1214	288	-1.4	1.3	3.15	450	449	223,365
529	452	0.251	1182	297	0	1.3	3.14	453	452	223,817
530	452	0.172	1208	208	0	2.6	3.14	453	452	224,269
531	451	0.179	1148	206	1.4	1.2	3.14	453	452	224,721
532	452	0.179	1179	211	0	1.3	3.13	453	452	225,173
533	452	0.195	1154	225	0	1.1	3.13	453	452	225,625
534	453	0.171	1161	199	-1.4	2.6	3.13	453	452	226,077
535	453	0.143	1170	167	0	1.2	3.13	453	452	226,529
536	453	0.114	1192	136	0	1.3	3.12	453	452	226,981
537	453	0.139	1191	165	0	1.3	3.12	453	452	227,433
538	453	0.114	1181	135	0	1.3	3.12	453	452	227,885
539	406	0.205	1194	245	2.8	12.0	3.13	453	452	228,337
540	415	0.268	1191	319	-1.4	1.3	3.13	453	452	228,789
541	415	0.236	1180	278	-2.8	2.0	3.13	453	452	229,241
542	415	0.200	1221	244	-1.4	1.2	3.12	453	452	229,693
543	415	0.158	1219	192	-1.4	1.3	3.12	453	452	230,145
544	415	0.174	1237	215	-1.4	1.2	3.12	453	452	230,597
545	415	0.239	1192	285	-1.4	1.2	3.11	453	452	231,049
546	416	0.161	1216	196	-1.4	2.6	3.11	453	452	231,501
547	416	0.147	1218	179	1.4	5.2	3.12	453	452	231,953
548	416	0.170	1202	204	2.8	2.5	3.11	453	452	232,405
549	416	0.240	1166	280	2.8	1.2	3.11	453	452	232,857
550	416	0.169	1208	204	2.8	2.5	3.11	453	452	233,309
551	406	0.090	1227	111	1.4	8.5	3.12	453	452	233,761
552	406	0.116	1224	142	0	1.3	3.12	453	452	234,213
553	406	0.168	1180	198	1.4	1.3	3.11	453	452	234,665
554	406	0.141	1193	168	1.4	1.2	3.11	453	452	235,117
555	406	0.092	1212	112	1.4	1.1	3.11	453	452	235,569
556	406	0.057	1241	71	1.4	1.2	3.10	453	452	236,021
557	406	0.204	1176	240	1.4	1.3	3.10	453	452	236,473
558	406	0.112	1226	137	1.4	1.2	3.10	453	452	236,925
559	406	0.058	1238	72	1.4	1.1	3.09	453	452	237,377
560	406	0.098	1246	122	2.8	1.3	3.09	453	452	237,829
561	406	0.218	1201	262	1.4	1.2	3.09	453	452	238,281
562	406	0.237	1175	278	1.4	4.0	3.09	453	452	238,733
563	406	0.195	1185	231	1.4	6.6	3.09	453	452	239,185
564	406	0.195	1177	230	1.4	1.2	3.09	453	452	239,637
565	406	0.129	1190	153	1.4	1.3	3.09	453	452	240,089
566	406	0.175	1192	209	1.4	1.2	3.08	453	452	240,541
567	406	0.052	1235	64	1.4	1.2	3.08	453	452	240,993
568	406	0.175	1215	213	0	1.2	3.08	453	452	241,445
569	415	0.216	1182	255	0	1.1	3.07	453	452	241,897
570	416	0.193	1189	230	5.6	2.2	3.07	453	452	242,349
571	406	0.164	1199	197	1.4	1.2	3.07	453	452	242,801
572	417	0.179	1209	216	-1.4	4.4	3.07	453	452	243,253
573	450	0.133	1211	161	-2.8	4.1	3.07	453	452	243,705
574	449	0.132	1202	159	2.8	1.1	3.07	453	452	244,157
575	447	0.090	1259	113	0	1.2	3.07	453	452	244,609
576	450	0.155	1217	189	0	5.0	3.07	453	452	245,061
577	447	0.207	1224	253	0	2.2	3.07	453	452	245,513
578	447	0.084	1260	106	0	1.2	3.07	453	452	245,965
579	448	0.126	1236	156	0	5.9	3.07	453	452	246,417
580	448	0.235	1212	285	0	1.1	3.07	453	452	246,869
581	448	0.121	1240	150	0	1.1	3.06	453	452	247,321
582	448	0.082	1261	103	0	2.3	3.06	453	452	247,773
583	447	0.199	1189	237	0	1.3	3.06	453	452	248,225
584	447	0.051	1278	65	0	1.3	3.06	453	452	248,677
585	447	0.047	1275	60	0	1.1	3.05	453	452	249,129
586	447	0.068	1274	86	0	1.2	3.05	453	452	249,581
587	447	0.048	1281	61	0	1.1	3.05	453	452	250,033
588	447	0.051	1280	65	0	1.2	3.04	453	452	250,485
589	447	0.076	1250	95	0	1.2	3.04	453	452	250,937
590	447	0.122	1234	151	0	1.2	3.04	453	452	251,389

591	447	0.201	1236	248	-1.4	2.5	3.04	453	452	251,841
592	447	0.078	1281	100	-1.4	1.2	3.03	453	452	252,293
593	447	0.080	1278	102	-1.4	1.2	3.03	453	452	252,745
594	447	0.091	1277	116	-1.4	1.2	3.03	453	452	253,197
595	447	0.109	1258	137	-1.4	1.2	3.02	453	452	253,649
596	417	0.152	1206	183	-1.4	1.3	3.02	453	452	254,101
597	417	0.174	1159	202	-1.4	1.2	3.02	453	452	254,553
598	417	0.233	1204	280	-1.4	9.3	3.03	453	452	255,005
599	417	0.214	1199	256	-1.4	2.6	3.03	453	452	255,457
600	417	0.213	1192	254	-1.4	5.2	3.03	453	452	255,909
601	417	0.204	1120	228	-5.6	1.2	3.03	453	452	256,361
602	406	0.063	1234	78	2.8	1.2	3.02	453	452	256,813
603	454	0.131	1209	158	1.4	4.0	3.03	455	454	257,267
604	454	0.159	1210	192	1.4	1.3	3.02	455	454	257,721
605	454	0.152	1220	186	1.4	1.3	3.02	455	454	258,175
606	454	0.111	1199	133	1.4	1.3	3.02	455	454	258,629
607	454	0.157	1200	188	1.4	1.3	3.02	455	454	259,083
608	455	0.171	1203	206	1.4	3.2	3.02	455	454	259,537
609	455	0.127	1216	154	1.4	1.2	3.01	455	454	259,991
610	455	0.105	1201	126	1.4	1.2	3.01	455	454	260,445
611	455	0.099	1215	120	1.4	1.3	3.01	455	454	260,899
612	455	0.114	1211	138	1.4	1.3	3.00	455	454	261,353
613	453	0.245	1141	279	-1.4	6.6	3.01	455	454	261,807
614	453	0.200	1137	227	-1.4	1.3	3.01	455	454	262,261
615	453	0.209	1146	240	0	2.6	3.01	455	454	262,715
616	453	0.193	1119	216	0	1.2	3.00	455	454	263,169
617	453	0.183	1147	210	0	1.3	3.00	455	454	263,623
618	453	0.270	1155	312	-1.4	7.4	3.01	455	454	264,077
619	453	0.234	1134	265	-1.4	1.2	3.00	455	454	264,531
620	453	0.168	1145	192	0	5.2	3.01	455	454	264,985
621	453	0.214	1138	244	-1.4	1.2	3.01	455	454	265,439
622	453	0.197	1153	227	-1.4	11.3	3.02	455	454	265,893
623	452	0.240	1169	281	1.4	4.6	3.02	455	454	266,347
624	452	0.279	1190	332	2.8	2.6	3.02	455	454	266,801
625	451	0.271	1143	310	2.8	3.8	3.02	455	454	267,255
626	452	0.214	1197	256	0	12.8	3.04	455	454	267,709
627	452	0.231	1149	265	1.4	1.2	3.03	455	454	268,163
628	452	0.218	1142	249	2.8	9.2	3.04	455	454	268,617
629	451	0.214	1139	244	2.8	1.3	3.04	455	454	269,071
630	452	0.222	1160	257	2.8	1.3	3.04	455	454	269,525
631	451	0.223	1100	245	4.2	1.2	3.04	455	454	269,979
632	447	0.080	1238	99	1.4	2.6	3.04	455	454	270,433
633	447	0.085	1214	103	1.4	1.2	3.03	455	454	270,887
634	447	0.071	1239	88	1.4	1.2	3.03	455	454	271,341
635	448	0.153	1225	187	1.4	1.3	3.03	455	454	271,795
636	448	0.220	1198	264	1.4	2.5	3.03	455	454	272,249
637	448	0.148	1234	183	1.4	1.2	3.02	455	454	272,703
638	448	0.250	1208	302	0	1.2	3.02	455	454	273,157
639	448	0.152	1240	188	0	1.1	3.02	455	454	273,611
640	448	0.175	1229	215	0	1.2	3.01	455	454	274,065
641	448	0.127	1235	157	1.4	2.6	3.01	455	454	274,519
642	448	0.182	1218	222	0	1.1	3.01	455	454	274,973
643	448	0.102	1264	129	0	1.3	3.01	455	454	275,427
644	406	0.141	1183	167	0	3.6	3.01	455	454	275,881
645	406	0.258	1201	310	0	5.3	3.01	455	454	276,335
646	406	0.242	1165	282	2.8	3.1	3.01	455	454	276,789
647	406	0.209	1182	247	0	3.3	3.01	455	454	277,243
648	406	0.131	1170	153	0	1.1	3.01	455	454	277,697
649	406	0.267	1160	310	0	1.1	3.01	455	454	278,151
650	407	0.189	1202	227	-1.4	1.1	3.00	455	454	278,605
651	407	0.198	1199	237	-1.4	1.1	3.00	455	454	279,059
652	407	0.229	1201	275	-1.4	1.1	3.00	455	454	279,513
653	407	0.255	1189	303	-2.8	1.1	3.00	455	454	279,967
654	407	0.261	1181	308	-2.8	1.1	2.99	455	454	280,421
655	415	0.275	1193	328	1.4	1.1	2.99	455	454	280,875
656	415	0.229	1195	274	1.4	1.1	2.99	455	454	281,329
657	415	0.248	1195	296	2.8	1.0	2.98	455	454	281,783
658	415	0.225	1211	272	2.8	1.1	2.98	455	454	282,237
659	415	0.268	1198	321	2.8	1.1	2.98	455	454	282,691
660	416	0.218	1186	259	4.2	4.3	2.98	455	454	283,145
661	416	0.269	1158	311	5.6	4.3	2.98	455	454	283,599
662	416	0.219	1175	257	5.6	1.1	2.98	455	454	284,053
663	416	0.181	1123	203	7	1.1	2.98	455	454	284,507
664	416	0.191	1164	222	7	1.1	2.97	455	454	284,961
665	416	0.242	1124	272	7	5.3	2.98	455	454	285,415

666	447	0.241	1185	286	1.4	5.3	2.98	455	454	285,869
667	447	0.078	1244	97	0	1.2	2.98	455	454	286,323
668	447	0.193	1216	235	0	1.2	2.98	455	454	286,777
669	447	0.110	1259	138	0	1.2	2.97	455	454	287,231
670	447	0.079	1238	98	0	1.1	2.97	455	454	287,685
671	447	0.097	1252	121	0	1.1	2.97	455	454	288,139
672	448	0.126	1216	153	0	1.1	2.96	455	454	288,593
673	448	0.116	1241	144	0	1.1	2.96	455	454	289,047
674	448	0.072	1273	92	0	1.1	2.96	455	454	289,501
675	448	0.101	1252	127	0	1.1	2.96	455	454	289,955
676	448	0.084	1279	107	0	1.1	2.95	455	454	290,409
677	417	0.230	1168	269	0	1.1	2.95	455	454	290,863
678	417	0.149	1195	178	1.4	1.1	2.95	455	454	291,317
679	417	0.141	1167	164	1.4	1.1	2.95	455	454	291,771
680	417	0.190	1199	228	1.4	1.1	2.94	455	454	292,225
681	417	0.222	1196	265	0	1.1	2.94	455	454	292,679
682	418	0.184	1162	214	4.2	1.1	2.94	455	454	293,133
683	418	0.217	1169	254	2.8	1.1	2.93	455	454	293,587
684	418	0.183	1163	213	2.8	1.2	2.93	455	454	294,041
685	418	0.191	1188	227	2.8	1.1	2.93	455	454	294,495
686	418	0.156	1183	184	2.8	1.2	2.93	455	454	294,949
687	453	0.189	1172	222	-1.4	11.9	2.94	455	454	295,403
688	453	0.231	1146	265	0	1.1	2.94	455	454	295,857
689	453	0.180	1169	210	-1.4	3.3	2.94	455	454	296,311
690	453	0.237	1164	276	-1.4	1.2	2.93	455	454	296,765
691	451	0.201	1142	230	5.6	8.2	2.94	455	454	297,219
692	451	0.268	1133	304	0	1.1	2.94	455	454	297,673
693	451	0.246	1145	282	0	1.1	2.94	455	454	298,127
694	451	0.157	1181	186	0	1.1	2.93	455	454	298,581
695	451	0.167	1178	197	0	1.1	2.93	455	454	299,035
696	451	0.200	1145	229	1.4	1.1	2.93	455	454	299,489
697	447	0.178	1227	218	0	7.9	2.94	455	454	299,943
698	447	0.090	1237	111	0	1.2	2.93	455	454	300,397
699	447	0.084	1249	105	0	1.2	2.93	455	454	300,851
700	447	0.080	1261	101	0	1.3	2.93	455	454	301,305
701	447	0.101	1259	127	0	1.3	2.93	455	454	301,759
702	448	0.154	1221	188	1.4	1.2	2.92	455	454	302,213
703	448	0.146	1207	176	1.4	1.2	2.92	455	454	302,667
704	448	0.105	1261	132	0	1.3	2.92	455	454	303,121
705	448	0.102	1261	128	0	1.2	2.92	455	454	303,575
706	448	0.068	1251	85	0	1.2	2.91	455	454	304,029
707	448	0.102	1229	125	0	1.1	2.91	455	454	304,483
708	448	0.078	1271	99	0	1.1	2.91	455	454	304,937
709	448	0.087	1261	110	0	1.2	2.91	455	454	305,391
710	406	0.209	1190	249	1.4	9.9	2.92	455	454	305,845
711	447	0.124	1245	155	0	8.7	2.93	455	454	306,299
712	447	0.084	1243	104	1.4	6.5	2.93	455	454	306,753
713	417	0.239	1204	288	-1.4	7.8	2.94	455	454	307,207
714	456	0.195	1183	231	2.8	21.3	2.96	457	456	307,663
715	472	0.099	1198	119	0	3.8	2.96	472	471	308,134
716	472	0.257	1160	298	0	1.1	2.96	472	471	308,605
717	472	0.236	1152	272	0	2.5	2.96	472	471	309,076
718	472	0.258	1130	292	0	4.9	2.96	472	471	309,547
719	458	0.072	1150	83	0	1.2	2.96	472	471	310,018
720	459	0.077	1157	89	0	2.5	2.96	472	471	310,489
721	460	0.041	1216	50	0	2.4	2.96	472	471	310,960
722	462	0.084	1140	96	0	8.9	2.97	472	471	311,431
723	463	0.085	1115	95	0	1.1	2.97	472	471	311,902
724	444	0.130	1111	144	0	1.2	2.96	472	471	312,373
725	444	0.212	1055	224	0	6.2	2.97	472	471	312,844
726	444	0.240	1071	257	-1.4	9.5	2.98	472	471	313,315
727	464	0.265	1066	282	0	1.1	2.97	472	471	313,786
728	465	0.049	1215	60	0	1.1	2.97	472	471	314,257
729	466	0.053	1196	63	0	1.1	2.97	472	471	314,728
730	467	0.090	1187	107	-1.4	4.9	2.97	472	471	315,199
731	468	0.058	1182	68	0	1.1	2.97	472	471	315,670
732	470	0.089	1206	107	0	2.4	2.97	472	471	316,141
733	470	0.141	1151	162	0	1.1	2.97	472	471	316,612
734	471	0.210	1147	241	1.4	2.5	2.96	472	471	317,083
735	471	0.135	1156	156	0	1.1	2.96	472	471	317,554
736	472	0.136	1166	159	0	1.1	2.96	472	471	318,025
737	472	0.090	1173	106	0	1.2	2.96	472	471	318,496
738	473	0.088	1234	108	-1.4	4.0	2.96	474	473	318,969
739	473	0.141	1233	174	-1.4	5.8	2.96	474	473	319,442
740	473	0.042	1278	54	-1.4	1.2	2.96	474	473	319,915

741	473	0.071	1251	89	-1.4	1.2	2.96	474	473	320,388
742	473	0.060	1260	75	-1.4	1.2	2.96	474	473	320,861
743	474	0.115	1220	140	0	3.2	2.96	474	473	321,334
744	474	0.075	1233	92	0	1.2	2.95	474	473	321,807
745	474	0.116	1215	141	0	1.3	2.95	474	473	322,280
746	474	0.116	1222	142	0	1.3	2.95	474	473	322,753
747	474	0.120	1198	144	0	1.3	2.95	474	473	323,226
748	474	0.115	1207	139	0	1.2	2.94	474	473	323,699
749	475	0.200	1149	230	-2.8	2.8	2.94	476	475	324,174
750	475	0.216	1151	249	-2.8	2.6	2.94	476	475	324,649
751	475	0.226	1179	267	-2.8	1.2	2.94	476	475	325,124
752	475	0.185	1165	215	-2.8	1.3	2.94	476	475	325,599
753	475	0.186	1176	219	-2.8	1.2	2.94	476	475	326,074
754	475	0.264	1166	308	-1.4	1.3	2.93	476	475	326,549
755	475	0.257	1148	295	-2.8	1.2	2.93	476	475	327,024
756	476	0.247	1171	289	1.4	1.3	2.93	476	475	327,499
757	476	0.103	1233	127	2.8	1.2	2.93	476	475	327,974
758	476	0.136	1203	164	2.8	1.3	2.93	476	475	328,449
759	476	0.158	1236	195	2.8	1.3	2.92	476	475	328,924
760	476	0.115	1226	141	2.8	1.3	2.92	476	475	329,399
761	476	0.150	1207	181	2.8	1.2	2.92	476	475	329,874
762	415	0.198	1196	237	0	1.1	2.92	476	475	330,349
763	415	0.165	1234	204	0	1.8	2.92	476	475	330,824
764	415	0.198	1199	238	0	2.5	2.91	476	475	331,299
765	415	0.162	1220	198	1.4	1.2	2.91	476	475	331,774
766	415	0.207	1176	244	1.4	1.2	2.91	476	475	332,249
767	416	0.224	1155	259	4.2	1.1	2.91	476	475	332,724
768	416	0.236	1122	265	4.2	1.2	2.91	476	475	333,199
769	416	0.196	1126	221	4.2	5.2	2.91	476	475	333,674
770	416	0.185	1152	213	2.8	2.5	2.91	476	475	334,149
771	416	0.167	1197	200	2.8	7.7	2.91	476	475	334,624
772	416	0.265	1143	303	4.2	1.1	2.91	476	475	335,099
773	458	0.088	1149	101	0	1.2	2.91	476	475	335,574
774	458	0.083	1165	97	0	1.2	2.91	476	475	336,049
775	458	0.080	1148	92	-1.4	1.2	2.91	476	475	336,524
776	458	0.089	1170	104	0	1.1	2.90	476	475	336,999
777	458	0.071	1155	82	0	1.2	2.90	476	475	337,474
778	458	0.105	1150	121	0	1.1	2.90	476	475	337,949
779	459	0.082	1155	95	0	2.5	2.90	476	475	338,424
780	459	0.058	1193	69	0	2.5	2.90	476	475	338,899
781	459	0.095	1169	111	0	2.5	2.90	476	475	339,374
782	459	0.247	1098	271	2.8	1.2	2.89	476	475	339,849
783	460	0.044	1233	54	0	1.1	2.89	476	475	340,324
784	460	0.066	1202	79	0	1.1	2.89	476	475	340,799
785	460	0.027	1241	34	0	1.1	2.89	476	475	341,274
786	460	0.104	1213	126	0	1.1	2.89	476	475	341,749
787	460	0.054	1208	65	0	1.1	2.88	476	475	342,224
788	460	0.058	1221	71	0	1.1	2.88	476	475	342,699
789	460	0.042	1226	52	0	1.1	2.88	476	475	343,174
790	460	0.057	1229	70	0	1.1	2.88	476	475	343,649
791	460	0.069	1219	84	0	1.0	2.87	476	475	344,124
792	461	0.059	1214	72	0	1.1	2.87	476	475	344,599
793	462	0.122	1111	135	0	2.5	2.87	476	475	345,074
794	462	0.114	1126	128	0	1.1	2.87	476	475	345,549
795	463	0.084	1119	94	0	1.2	2.87	476	475	346,024
796	463	0.141	1091	154	0	1.1	2.87	476	475	346,499
797	444	0.230	1134	261	0	1.1	2.86	476	475	346,974
798	464	0.097	1160	113	0	1.1	2.86	476	475	347,449
799	465	0.070	1191	83	0	1.1	2.86	476	475	347,924
800	465	0.089	1191	106	0	1.2	2.86	476	475	348,399
801	465	0.083	1210	100	0	1.2	2.85	476	475	348,874
802	465	0.072	1212	87	0	1.1	2.85	476	475	349,349
803	465	0.081	1213	98	0	1.2	2.85	476	475	349,824
804	465	0.061	1224	75	0	1.2	2.85	476	475	350,299
805	466	0.028	1235	35	0	1.1	2.85	476	475	350,774
806	466	0.085	1168	99	0	1.1	2.84	476	475	351,249
807	466	0.025	1230	31	0	1.1	2.84	476	475	351,724
808	466	0.027	1252	34	0	1.1	2.84	476	475	352,199
809	467	0.102	1169	119	0	1.1	2.84	476	475	352,674
810	468	0.029	1207	35	0	1.1	2.84	476	475	353,149
811	468	0.026	1230	32	0	1.1	2.83	476	475	353,624
812	468	0.034	1198	41	0	1.0	2.83	476	475	354,099
813	468	0.023	1216	28	0	1.1	2.83	476	475	354,574
814	468	0.131	1160	152	-1.4	1.1	2.83	476	475	355,049
815	468	0.066	1184	78	-1.4	1.2	2.82	476	475	355,524

816	469	0.145	1196	173	0	1.1	2.82	476	475	355,999
817	470	0.102	1169	119	0	8.9	2.83	476	475	356,474
818	470	0.131	1164	152	0	1.1	2.83	476	475	356,949
819	470	0.182	1137	207	0	1.2	2.83	476	475	357,424
820	470	0.152	1140	173	0	1.1	2.82	476	475	357,899
821	471	0.150	1150	173	1.4	1.2	2.82	476	475	358,374
822	471	0.127	1143	145	1.4	1.1	2.82	476	475	358,849
823	471	0.150	1161	174	1.4	1.1	2.82	476	475	359,324
824	471	0.148	1181	175	0	1.1	2.82	476	475	359,799
825	471	0.117	1195	140	0	1.1	2.81	476	475	360,274
826	472	0.079	1193	94	0	1.2	2.81	476	475	360,749
827	472	0.094	1180	111	0	1.1	2.81	476	475	361,224
828	445	0.057	1208	69	0	1.1	2.81	476	475	361,699
829	445	0.263	1122	295	-1.4	1.2	2.81	476	475	362,174
830	445	0.139	1177	164	0	1.1	2.80	476	475	362,649
831	445	0.130	1183	154	0	1.1	2.80	476	475	363,124
832	445	0.228	1153	263	0	1.1	2.80	476	475	363,599
833	445	0.210	1133	238	0	1.2	2.80	476	475	364,074
834	445	0.184	1150	212	0	1.2	2.80	476	475	364,549
835	445	0.181	1143	207	0	1.1	2.79	476	475	365,024
836	446	0.082	1173	96	0	1.2	2.79	476	475	365,499
837	446	0.074	1206	89	0	1.2	2.79	476	475	365,974
838	446	0.081	1196	97	0	1.2	2.79	476	475	366,449
839	446	0.080	1179	94	0	1.1	2.79	476	475	366,924
840	446	0.102	1179	120	0	1.2	2.78	476	475	367,399
841	446	0.162	1140	185	-1.4	1.1	2.78	476	475	367,874
842	447	0.258	1167	301	0	3.1	2.78	476	475	368,349
843	447	0.206	1192	246	0	2.6	2.78	476	475	368,824
844	447	0.237	1158	275	1.4	1.2	2.78	476	475	369,299
845	447	0.204	1192	243	0	2.5	2.78	476	475	369,774
846	447	0.224	1187	266	0	1.3	2.78	476	475	370,249
847	447	0.237	1201	285	0	9.3	2.79	476	475	370,724
848	447	0.220	1205	265	0	1.2	2.78	476	475	371,199
849	447	0.221	1204	266	0	1.2	2.78	476	475	371,674
850	447	0.231	1204	278	0	1.2	2.78	476	475	372,149
851	447	0.189	1218	230	-1.4	1.2	2.78	476	475	372,624
852	447	0.206	1212	250	-1.4	1.2	2.78	476	475	373,099
853	447	0.262	1212	318	-1.4	1.2	2.77	476	475	373,574
854	447	0.225	1219	274	0	1.2	2.77	476	475	374,049
855	447	0.223	1198	267	1.4	1.2	2.77	476	475	374,524
856	447	0.196	1210	237	0	2.5	2.77	476	475	374,999
857	447	0.203	1234	250	0	11.4	2.78	476	475	375,474
858	447	0.214	1208	259	0	4.4	2.78	476	475	375,949
859	447	0.197	1228	242	0	1.2	2.78	476	475	376,424
860	447	0.270	1199	324	0	1.2	2.78	476	475	376,899
861	447	0.206	1213	250	0	1.2	2.78	476	475	377,374
862	447	0.174	1233	214	0	1.2	2.77	476	475	377,849
863	447	0.251	1202	302	-1.4	1.2	2.77	476	475	378,324
864	447	0.149	1203	179	0	1.2	2.77	476	475	378,799
865	447	0.172	1212	208	-1.4	1.2	2.77	476	475	379,274
866	447	0.214	1210	259	-1.4	1.3	2.77	476	475	379,749
867	447	0.220	1206	265	0	1.3	2.77	476	475	380,224
868	447	0.161	1207	194	-1.4	1.3	2.76	476	475	380,699
869	447	0.148	1229	182	-1.4	1.1	2.76	476	475	381,174
870	447	0.197	1206	237	-1.4	1.2	2.76	476	475	381,649
871	447	0.153	1232	189	0	1.2	2.76	476	475	382,124
872	447	0.208	1219	253	0	1.2	2.76	476	475	382,599
873	447	0.218	1201	262	-1.4	1.2	2.76	476	475	383,074
874	447	0.209	1213	254	-1.4	3.7	2.76	476	475	383,549
875	447	0.180	1225	221	0	3.8	2.76	476	475	384,024
876	447	0.150	1210	182	0	6.3	2.76	476	475	384,499
877	447	0.208	1219	253	0	1.2	2.76	476	475	384,974
878	447	0.218	1201	262	-1.4	1.2	2.76	476	475	385,449
879	447	0.209	1213	254	-1.4	3.7	2.76	476	475	385,924
880	447	0.180	1225	221	0	3.8	2.76	476	475	386,399
881	447	0.150	1210	182	0	6.3	2.76	476	475	386,874
882	447	0.172	1238	213	0	4.7	2.77	476	475	387,349
883	447	0.182	1237	225	0	1.1	2.76	476	475	387,824
884	447	0.196	1221	239	0	1.3	2.76	476	475	388,299
885	447	0.186	1244	231	-1.4	1.2	2.76	476	475	388,774
886	447	0.209	1218	255	0	1.2	2.76	476	475	389,249
887	447	0.237	1197	284	0	8.9	2.77	476	475	389,724
888	447	0.161	1244	200	0	2.6	2.77	476	475	390,199
889	447	0.122	1255	153	0	1.2	2.76	476	475	390,674
890	447	0.129	1248	161	0	1.1	2.76	476	475	391,149

891	447	0.085	1255	107	0	1.2	2.76	476	475	391,624
892	447	0.190	1230	234	0	1.2	2.76	476	475	392,099
893	447	0.195	1188	232	1.4	2.5	2.76	476	475	392,574
894	447	0.129	1209	156	1.4	3.8	2.76	476	475	393,049
895	447	0.221	1228	271	0	1.2	2.76	476	475	393,524
896	447	0.192	1237	238	0	1.2	2.76	476	475	393,999
897	447	0.131	1249	164	0	1.2	2.75	476	475	394,474
898	478	0.074	1235	91	0	1.3	2.75	479	478	394,952
899	478	0.091	1224	111	0	1.2	2.75	479	478	395,430
900	478	0.082	1229	101	0	1.2	2.75	479	478	395,908
901	478	0.084	1255	106	0	1.1	2.75	479	478	396,386
902	478	0.107	1219	131	0	1.3	2.75	479	478	396,864
903	479	0.152	1212	184	0	1.2	2.74	479	478	397,342
904	479	0.081	1244	101	0	1.2	2.74	479	478	397,820
905	479	0.131	1217	159	0	1.2	2.74	479	478	398,298
906	479	0.181	1189	215	0	1.2	2.74	479	478	398,776
907	479	0.166	1200	199	0	1.3	2.74	479	478	399,254
908	480	0.155	1249	193	0	4.7	2.74	482	481	399,735
909	480	0.116	1313	152	0	1.3	2.74	482	481	400,216
910	480	0.171	1264	216	0	1.2	2.74	482	481	400,697
911	480	0.173	1241	215	0	1.2	2.74	482	481	401,178
912	480	0.171	1248	214	0	1.2	2.73	482	481	401,659
913	480	0.106	1255	133	-1.4	2.5	2.73	482	481	402,140
914	482	0.277	1184	328	0	2.0	2.73	482	481	402,621
915	482	0.167	1222	204	0	1.3	2.73	482	481	403,102
916	482	0.133	1234	164	0	1.2	2.73	482	481	403,583
917	482	0.078	1248	97	0	1.2	2.73	482	481	404,064
918	482	0.119	1242	148	0	1.2	2.73	482	481	404,545
919	482	0.092	1237	114	0	1.3	2.72	482	481	405,026
920	482	0.095	1259	120	0	1.1	2.72	482	481	405,507
921	482	0.123	1186	146	4.2	1.2	2.72	482	481	405,988
922	482	0.132	1201	158	2.8	1.2	2.72	482	481	406,469
923	480	0.164	1233	202	0	1.3	2.72	482	481	406,950
924	480	0.146	1202	175	1.4	1.2	2.72	482	481	407,431
925	480	0.262	1170	307	0	1.1	2.71	482	481	407,912
926	482	0.105	1231	129	0	2.3	2.71	482	481	408,393
927	406	0.117	1199	140	2.8	5.5	2.72	482	481	408,874
928	415	0.191	1211	231	2.8	1.1	2.71	482	481	409,355
929	484	0.234	1160	272	1.4	2.0	2.71	484	483	409,838
930	484	0.126	1212	153	0	1.3	2.71	484	483	410,321
931	484	0.095	1227	116	-1.4	1.3	2.71	484	483	410,804
932	484	0.089	1246	111	0	1.3	2.71	484	483	411,287
933	484	0.075	1251	94	-1.4	1.3	2.71	484	483	411,770
934	483	0.229	1089	249	-2.8	1.2	2.71	484	483	412,253
935	483	0.174	1158	202	-1.4	1.2	2.70	484	483	412,736
936	483	0.132	1172	155	-1.4	1.3	2.70	484	483	413,219
937	483	0.112	1156	129	-1.4	1.3	2.70	484	483	413,702
938	483	0.141	1156	163	-1.4	1.2	2.70	484	483	414,185
939	484	0.189	1191	225	0	1.1	2.70	484	483	414,668
940	483	0.120	1192	143	0	6.5	2.70	484	483	415,151
941	485	0.101	1235	125	0	3.3	2.70	486	485	415,636
942	485	0.086	1232	106	1.4	1.4	2.70	486	485	416,121
943	485	0.126	1168	147	1.4	1.3	2.70	486	485	416,606
944	485	0.118	1219	144	1.4	1.3	2.70	486	485	417,091
945	485	0.137	1192	163	1.4	1.2	2.70	486	485	417,576
946	485	0.161	1182	190	1.4	1.3	2.70	486	485	418,061
947	486	0.123	1204	148	0	1.3	2.69	486	485	418,546
948	486	0.201	1198	241	0	1.8	2.69	486	485	419,031
949	486	0.197	1192	235	2.8	2.0	2.69	486	485	419,516
950	486	0.111	1210	134	1.4	2.6	2.69	486	485	420,001
951	486	0.145	1196	174	2.8	2.6	2.69	486	485	420,486
952	486	0.125	1236	155	1.4	1.3	2.69	486	485	420,971
953	486	0.116	1204	140	0	2.9	2.69	486	485	421,456
954	486	0.101	1253	126	-1.4	1.2	2.69	486	485	421,941
955	486	0.088	1223	108	0	1.1	2.69	486	485	422,426
956	486	0.072	1251	90	0	1.2	2.69	486	485	422,911
957	485	0.157	1159	182	1.4	3.3	2.69	486	485	423,396
958	447	0.192	1198	230	0	1.3	2.69	486	485	423,881
959	448	0.137	1223	167	1.4	2.7	2.69	486	485	424,366
960	448	0.224	1216	272	0	2.6	2.69	486	485	424,851
961	447	0.200	1200	240	1.4	2.6	2.69	486	485	425,336
962	447	0.160	1219	195	2.8	2.6	2.69	486	485	425,821
963	447	0.142	1222	174	1.4	2.5	2.69	486	485	426,306
964	447	0.175	1219	213	0	1.3	2.68	486	485	426,791
965	448	0.178	1250	223	0	1.2	2.68	486	485	427,276

966	415	0.279	1200	335	0	1.3	2.68	486	485	427,761
967	415	0.254	1187	301	-2.8	3.9	2.68	486	485	428,246
968	406	0.203	1175	238	1.4	4.0	2.68	486	485	428,731
969	406	0.250	1179	295	2.8	1.2	2.68	486	485	429,216
970	406	0.205	1173	241	1.4	1.2	2.68	486	485	429,701
971	415	0.243	1196	291	-2.8	1.9	2.68	486	485	430,186
972	416	0.202	1162	235	8.4	1.2	2.68	486	485	430,671
973	484	0.215	1181	254	0	2.0	2.68	486	485	431,156
974	483	0.133	1157	154	-1.4	4.0	2.68	486	485	431,641
975	415	0.272	1110	302	4.2	6.8	2.68	486	485	432,126
976	416	0.188	1157	217	7	2.6	2.68	486	485	432,611
977	111	0.249	1183	294	0	6.7	2.69	486	485	433,096
978	111	0.268	1157	310	1.4	1.3	2.69	486	485	433,581
979	111	0.271	1157	313	2.8	3.8	2.69	486	485	434,066
980	111	0.214	1153	247	1.4	1.3	2.69	486	485	434,551
981	111	0.263	1153	303	1.4	1.3	2.68	486	485	435,036
982	111	0.280	1164	326	2.8	6.6	2.69	486	485	435,521
983	111	0.235	1164	274	2.8	3.9	2.69	486	485	436,006
984	111	0.220	1161	256	1.4	1.1	2.69	486	485	436,491
985	111	0.273	1151	314	1.4	5.2	2.69	486	485	436,976
986	111	0.224	1149	257	1.4	1.9	2.69	486	485	437,461
987	111	0.247	1158	286	1.4	1.3	2.69	486	485	437,946
988	487	0.170	1190	202	0	2.5	2.69	487	486	438,432
989	487	0.095	1195	113	0	1.2	2.69	487	486	438,918
990	487	0.131	1212	159	0	1.2	2.68	487	486	439,404
991	487	0.101	1203	122	-1.4	1.1	2.68	487	486	439,890
992	487	0.119	1175	140	-1.4	1.1	2.68	487	486	440,376
993	487	0.154	1205	186	0	1.1	2.68	487	486	440,862
994	486	0.092	1243	114	-1.4	1.2	2.68	487	486	441,348
995	486	0.088	1266	111	0	1.2	2.68	487	486	441,834
996	486	0.116	1238	144	0	1.2	2.68	487	486	442,320
997	486	0.115	1247	144	0	1.2	2.67	487	486	442,806
998	485	0.181	1185	215	-1.4	3.8	2.68	487	486	443,292
999	9	0.229	1139	261	4.2	5.1	2.68	487	486	443,778
1000	9	0.264	1180	312	2.8	3.8	2.68	487	486	444,264
1001	10	0.255	1165	297	-4.2	5.4	2.68	487	486	444,750
1002	177	0.265	1184	314	-1.4	9.2	2.69	487	486	445,236
1003	176	0.271	1166	316	-1.4	11.0	2.70	487	486	445,722
1004	491	0.216	1189	257	0	5.1	2.70	491	490	446,212
1005	489	0.085	1236	105	0	2.6	2.70	491	490	446,702
1006	447	0.197	1205	237	0	1.3	2.70	491	490	447,192
1007	447	0.144	1229	177	0	1.3	2.70	491	490	447,682
1008	447	0.141	1244	176	0	1.2	2.69	491	490	448,172
1009	484	0.077	1213	93	0	14.4	2.71	491	490	448,662
1010	415	0.281	1173	330	1.4	4.1	2.71	491	490	449,152
1011	415	0.215	1220	262	-1.4	1.2	2.71	491	490	449,642
1012	416	0.166	1187	197	2.8	1.2	2.70	491	490	450,132
1013	453	0.228	1160	264	-2.8	4.6	2.71	491	490	450,622
1014	452	0.215	1203	259	0	3.1	2.71	491	490	451,112
1015	451	0.211	1143	241	1.4	2.6	2.71	491	490	451,602
1016	452	0.216	1197	259	0	5.8	2.71	491	490	452,092
1017	95	0.227	1165	265	-4.2	8.5	2.72	491	490	452,582
1018	95	0.268	1155	310	-2.8	3.3	2.72	491	490	453,072
1019	95	0.236	1142	269	-5.6	5.2	2.72	491	490	453,562
1020	484	0.126	1189	150	1.4	1.2	2.72	491	490	454,052
1021	484	0.149	1182	176	0	1.3	2.72	491	490	454,542
1022	484	0.112	1251	140	0	1.2	2.71	491	490	455,032
1023	484	0.213	1186	253	0	2.5	2.71	491	490	455,522
1024	484	0.152	1222	186	0	1.2	2.71	491	490	456,012
1025	415	0.177	1234	219	0	4.6	2.71	491	490	456,502
1026	416	0.175	1162	203	4.2	2.5	2.71	491	490	456,992
1027	415	0.269	1189	320	0	2.4	2.71	491	490	457,482
1028	415	0.253	1211	306	1.4	1.1	2.71	491	490	457,972
1029	415	0.240	1198	287	1.4	1.2	2.71	491	490	458,462
1030	415	0.229	1206	276	2.8	1.2	2.71	491	490	458,952
1031	415	0.215	1202	258	2.8	1.1	2.71	491	490	459,442
1032	416	0.263	1131	298	7	1.2	2.71	491	490	459,932
1033	416	0.221	1123	248	7	2.5	2.71	491	490	460,422
1034	416	0.244	1117	272	8.4	2.5	2.71	491	490	460,912
1035	416	0.193	1137	219	8.4	1.2	2.70	491	490	461,402
1036	416	0.247	1138	281	8.4	1.1	2.70	491	490	461,892
1037	415	0.199	1204	239	-1.4	1.2	2.70	491	490	462,382
1038	415	0.279	1217	340	-1.4	1.2	2.70	491	490	462,872
1039	415	0.211	1245	263	0	1.2	2.70	491	490	463,362
1040	415	0.247	1225	302	0	1.1	2.70	491	490	463,852

1041	415	0.252	1203	303	1.4	1.1	2.70	491	490	464,342
1042	415	0.267	1214	324	0	1.2	2.69	491	490	464,832
1043	415	0.213	1216	259	1.4	1.2	2.69	491	490	465,322
1044	415	0.251	1165	292	1.4	2.5	2.69	491	490	465,812
1045	415	0.237	1187	281	1.4	1.2	2.69	491	490	466,302
1046	415	0.160	1209	193	1.4	1.2	2.69	491	490	466,792
1047	415	0.266	1161	309	1.4	1.2	2.69	491	490	467,282
1048	416	0.265	1141	302	8.4	1.2	2.69	491	490	467,772
1049	416	0.236	1147	271	8.4	6.6	2.69	491	490	468,262
1050	416	0.275	1151	316	8.4	1.2	2.69	491	490	468,752
1051	416	0.258	1141	294	8.4	2.5	2.69	491	490	469,242
1052	416	0.243	1138	276	8.4	3.8	2.69	491	490	469,732
1053	416	0.246	1140	281	8.4	2.5	2.69	491	490	470,222
1054	416	0.239	1148	274	8.4	2.5	2.69	491	490	470,712
1055	416	0.255	1155	294	8.4	1.2	2.69	491	490	471,202
1056	416	0.269	1128	303	9.8	1.4	2.69	491	490	471,692
1057	416	0.207	1157	240	8.4	2.5	2.69	491	490	472,182
1058	415	0.248	1184	294	0	3.1	2.69	491	490	472,672
1059	484	0.129	1173	151	2.8	3.1	2.69	491	490	473,162
1060	484	0.113	1151	130	1.4	1.3	2.69	491	490	473,652
1061	484	0.163	1141	186	2.8	1.3	2.68	491	490	474,142
1062	484	0.200	1139	228	1.4	3.8	2.69	491	490	474,632
1063	484	0.153	1184	181	2.8	1.3	2.68	491	490	475,122
1064	486	0.159	1169	186	-2.8	3.2	2.68	491	490	475,612
1065	492	0.201	1218	245	-1.4	5.4	2.69	493	492	476,104
1066	492	0.215	1230	264	-1.4	2.5	2.69	493	492	476,596
1067	492	0.260	1195	311	-1.4	1.2	2.69	493	492	477,088
1068	492	0.213	1204	257	-2.8	1.2	2.68	493	492	477,580
1069	492	0.098	1240	121	-2.8	1.2	2.68	493	492	478,072
1070	492	0.064	1266	81	-2.8	1.2	2.68	493	492	478,564
1071	493	0.105	1223	128	0	5.1	2.68	493	492	479,056
1072	493	0.252	1188	299	0	1.2	2.68	493	492	479,548
1073	493	0.210	1181	248	0	1.1	2.68	493	492	480,040
1074	493	0.114	1207	137	0	1.2	2.68	493	492	480,532
1075	493	0.170	1203	205	0	1.2	2.68	493	492	481,024
1076	493	0.252	1176	296	0	3.8	2.68	493	492	481,516
1077	415	0.194	1192	231	1.4	1.2	2.68	493	492	482,008
1078	415	0.183	1190	218	1.4	1.2	2.68	493	492	482,500
1079	415	0.219	1181	259	1.4	1.2	2.68	493	492	482,992
1080	415	0.158	1196	189	1.4	1.1	2.67	493	492	483,484
1081	415	0.192	1207	232	2.8	1.1	2.67	493	492	483,976
1082	416	0.252	1114	281	5.6	8.1	2.68	493	492	484,468
1083	416	0.217	1099	238	5.6	1.2	2.68	493	492	484,960
1084	416	0.276	1108	306	5.6	4.0	2.68	493	492	485,452
1085	416	0.263	1112	292	5.6	3.7	2.68	493	492	485,944
1086	416	0.263	1141	300	4.2	3.8	2.68	493	492	486,436
1087	447	0.251	1188	298	1.4	3.1	2.68	493	492	486,928
1088	447	0.195	1165	227	1.4	2.4	2.68	493	492	487,420
1089	447	0.242	1190	288	1.4	2.5	2.68	493	492	487,912
1090	458	0.065	1182	77	0	1.2	2.68	493	492	488,404
1091	458	0.112	1147	129	0	1.1	2.68	493	492	488,896
1092	458	0.103	1160	120	0	1.2	2.67	493	492	489,388
1093	459	0.059	1205	71	0	1.1	2.67	493	492	489,880
1094	461	0.055	1245	69	0	1.1	2.67	493	492	490,372
1095	462	0.182	1099	200	0	2.5	2.67	493	492	490,864
1096	463	0.101	1107	112	0	1.2	2.67	493	492	491,356
1097	463	0.182	1094	199	0	1.1	2.67	493	492	491,848
1098	463	0.227	1055	240	-1.4	1.1	2.67	493	492	492,340
1099	463	0.143	1120	160	0	1.1	2.67	493	492	492,832
1100	444	0.189	1071	202	-1.4	7.5	2.67	493	492	493,324
1101	444	0.105	1138	119	0	1.1	2.67	493	492	493,816
1102	464	0.053	1179	62	0	1.1	2.67	493	492	494,308
1103	464	0.034	1209	41	0	1.1	2.67	493	492	494,800
1104	465	0.059	1216	72	0	1.2	2.66	493	492	495,292
1105	465	0.045	1217	55	0	1.2	2.66	493	492	495,784
1106	465	0.046	1221	56	0	1.1	2.66	493	492	496,276
1107	465	0.118	1173	138	0	1.2	2.66	493	492	496,768
1108	465	0.078	1214	95	0	1.1	2.66	493	492	497,260
1109	466	0.040	1236	50	0	1.1	2.66	493	492	497,752
1110	466	0.040	1210	48	0	1.1	2.66	493	492	498,244
1111	466	0.047	1204	57	0	1.1	2.66	493	492	498,736
1112	466	0.041	1216	50	0	1.1	2.65	493	492	499,228
1113	467	0.084	1196	101	0	5.0	2.66	493	492	499,720
1114	467	0.103	1165	120	0	1.1	2.65	493	492	500,212
1115	467	0.070	1214	85	0	1.0	2.65	493	492	500,704

1116	468	0.034	1190	41	0	2.4	2.65	493	492	501,196
1117	468	0.054	1212	66	-1.4	1.1	2.65	493	492	501,688
1118	468	0.135	1165	157	-1.4	1.2	2.65	493	492	502,180
1119	468	0.050	1235	62	-1.4	1.1	2.65	493	492	502,672
1120	470	0.127	1159	147	0	1.1	2.65	493	492	503,164
1121	470	0.165	1144	189	0	1.1	2.65	493	492	503,656
1122	470	0.125	1145	143	0	1.2	2.64	493	492	504,148
1123	470	0.147	1148	169	0	1.2	2.64	493	492	504,640
1124	471	0.164	1157	190	1.4	8.4	2.65	493	492	505,132
1125	471	0.140	1149	161	1.4	1.2	2.65	493	492	505,624
1126	471	0.173	1171	202	1.4	1.1	2.65	493	492	506,116
1127	471	0.141	1167	164	0	1.2	2.64	493	492	506,608
1128	472	0.066	1183	78	0	1.2	2.64	493	492	507,100
1129	472	0.067	1189	80	0	1.2	2.64	493	492	507,592
1130	472	0.079	1202	95	0	1.2	2.64	493	492	508,084
1131	472	0.076	1204	92	0	1.2	2.64	493	492	508,576
1132	445	0.202	1152	233	0	1.2	2.64	493	492	509,068
1133	445	0.153	1129	173	0	1.1	2.64	493	492	509,560
1134	446	0.170	1155	196	0	1.2	2.64	493	492	510,052
1135	446	0.075	1185	89	0	1.1	2.63	493	492	510,544
1136	446	0.079	1183	94	0	1.2	2.63	493	492	511,036
1137	446	0.126	1167	147	0	1.2	2.63	493	492	511,528
1138	477	0.083	1182	98	0	1.1	2.63	493	492	512,020
1139	478	0.233	1225	285	0	1.1	2.63	493	492	512,512
1140	478	0.077	1240	96	0	1.1	2.63	493	492	513,004
1141	478	0.126	1237	156	0	1.2	2.63	493	492	513,496
1142	479	0.187	1217	227	0	1.1	2.63	493	492	513,988
1143	479	0.134	1211	162	0	1.2	2.62	493	492	514,480
1144	479	0.102	1236	126	0	1.2	2.62	493	492	514,972
1145	415	0.192	1221	234	-1.4	1.3	2.62	493	492	515,464
1146	415	0.144	1215	175	0	2.6	2.62	493	492	515,956
1147	415	0.187	1204	225	0	2.5	2.62	493	492	516,448
1148	415	0.141	1236	174	0	1.1	2.62	493	492	516,940
1149	415	0.188	1221	229	1.4	1.2	2.62	493	492	517,432
1150	415	0.266	1194	318	-1.4	5.0	2.62	493	492	517,924
1151	416	0.264	1200	317	-1.4	1.1	2.62	493	492	518,416
1152	406	0.160	1224	196	0	2.3	2.62	493	492	518,908
1153	407	0.238	1182	281	0	1.1	2.62	493	492	519,400
1154	407	0.145	1197	173	1.4	1.0	2.62	493	492	519,892
1155	406	0.102	1209	123	1.4	1.1	2.62	493	492	520,384
1156	447	0.133	1255	167	0	1.1	2.61	493	492	520,876
1157	448	0.106	1248	132	0	2.2	2.61	493	492	521,368
1158	448	0.183	1201	220	-1.4	4.3	2.62	493	492	521,860
1159	417	0.235	1156	272	-2.8	3.7	2.62	493	492	522,352
1160	417	0.181	1120	203	-2.8	8.7	2.62	493	492	522,844
1161	417	0.211	1036	219	-19.7	7.8	2.63	493	492	523,336
1162	495	0.100	1209	121	1.4	13.4	2.63	495	494	523,830
1163	494	0.241	1216	293	0	3.8	2.64	495	494	524,324
1164	494	0.275	1215	334	0	1.1	2.63	495	494	524,818
1165	495	0.206	1162	239	7	1.2	2.63	495	494	525,312
1166	495	0.278	1185	329	1.4	4.4	2.63	495	494	525,806
1167	494	0.271	1190	322	-4.2	3.1	2.64	495	494	526,300
1168	494	0.245	1262	309	-1.4	3.1	2.64	495	494	526,794
1169	406	0.037	1255	46	0	3.2	2.64	495	494	527,288
1170	407	0.139	1194	166	1.4	5.8	2.64	495	494	527,782
1171	415	0.209	1208	253	-1.4	6.7	2.64	495	494	528,276
1172	415	0.165	1191	196	1.4	3.2	2.64	495	494	528,770
1173	484	0.167	1163	194	0	4.4	2.64	495	494	529,264
1174	447	0.120	1228	147	1.4	5.0	2.65	495	494	529,758
1175	448	0.243	1195	290	1.4	4.6	2.65	495	494	530,252
1176	448	0.221	1197	265	0	3.8	2.65	495	494	530,746
1177	448	0.261	1169	305	1.4	5.0	2.65	495	494	531,240
1178	448	0.081	1248	101	1.4	3.7	2.65	495	494	531,734
1179	484	0.200	1170	234	1.4	3.1	2.65	495	494	532,228
1180	484	0.114	1240	141	0	5.1	2.65	495	494	532,722
1181	406	0.125	1213	152	0	6.9	2.66	495	494	533,216
1182	407	0.210	1164	244	1.4	9.2	2.66	495	494	533,710
1183	447	0.140	1229	172	0	3.4	2.66	495	494	534,204
1184	447	0.144	1233	178	-1.4	6.2	2.67	495	494	534,698
1185	447	0.256	1202	308	0	4.1	2.67	495	494	535,192
1186	447	0.161	1277	205	0	5.1	2.67	495	494	535,686
1187	447	0.192	1234	237	0	4.1	2.67	495	494	536,180
1188	447	0.195	1209	236	1.4	2.9	2.67	495	494	536,674
1189	484	0.168	1176	198	1.4	5.2	2.67	495	494	537,168
1190	484	0.122	1218	149	1.4	1.9	2.67	495	494	537,662

1191	484	0.117	1202	141	2.8	5.3	2.68	495	494	538,156
1192	484	0.223	1112	248	5.6	3.1	2.68	495	494	538,650
1193	484	0.214	1148	246	5.6	1.2	2.67	495	494	539,144
1194	484	0.182	1176	214	5.6	1.3	2.67	495	494	539,638
1195	484	0.253	1156	292	2.8	1.2	2.67	495	494	540,132
1196	484	0.133	1197	159	2.8	1.2	2.67	495	494	540,626
1197	484	0.117	1201	141	1.4	1.3	2.67	495	494	541,120
1198	484	0.127	1209	154	1.4	1.2	2.67	495	494	541,614
1199	447	0.107	1229	132	1.4	3.7	2.67	495	494	542,108
1200	447	0.158	1229	194	0	1.2	2.67	495	494	542,602
1201	447	0.151	1241	187	0	1.2	2.67	495	494	543,096
1202	447	0.135	1238	167	0	1.2	2.67	495	494	543,590
1203	447	0.205	1220	250	0	1.2	2.66	495	494	544,084
1204	447	0.235	1212	285	0	1.2	2.66	495	494	544,578
1205	447	0.099	1244	123	0	1.3	2.66	495	494	545,072
1206	447	0.144	1224	176	0	1.2	2.66	495	494	545,566
1207	447	0.161	1229	198	0	1.2	2.66	495	494	546,060
1208	447	0.151	1243	188	0	1.2	2.66	495	494	546,554
1209	447	0.216	1219	263	0	1.2	2.66	495	494	547,048
1210	447	0.203	1225	249	-1.4	1.3	2.66	495	494	547,542
1211	447	0.152	1215	185	-1.4	1.2	2.65	495	494	548,036
1212	447	0.177	1225	217	-1.4	1.2	2.65	495	494	548,530
1213	447	0.168	1210	203	-1.4	1.2	2.65	495	494	549,024
1214	447	0.141	1230	174	-1.4	1.1	2.65	495	494	549,518
1215	447	0.163	1230	201	-1.4	1.2	2.65	495	494	550,012
1216	447	0.158	1216	192	-1.4	1.1	2.65	495	494	550,506
1217	447	0.212	1216	258	-1.4	1.2	2.65	495	494	551,000
1218	447	0.148	1227	182	0	1.1	2.65	495	494	551,494
1219	447	0.188	1226	230	0	1.2	2.65	495	494	551,988
1220	447	0.088	1257	110	0	1.2	2.64	495	494	552,482
1221	417	0.277	1168	324	-5.6	7.5	2.65	495	494	552,976
1222	417	0.216	1175	254	2.8	13.4	2.66	495	494	553,470
1223	417	0.266	1182	315	1.4	5.9	2.66	495	494	553,964
1224	484	0.174	1153	201	0	2.5	2.66	495	494	554,458
1225	484	0.160	1153	184	2.8	4.4	2.66	495	494	554,952
1226	484	0.176	1147	202	0	2.6	2.66	495	494	555,446
1227	484	0.219	1159	254	0	1.3	2.66	495	494	555,940
1228	484	0.137	1207	165	0	1.2	2.66	495	494	556,434
1229	484	0.141	1195	169	0	1.2	2.66	495	494	556,928
1230	484	0.207	1176	244	0	1.3	2.66	495	494	557,422
1231	484	0.232	1137	264	4.2	2.5	2.66	495	494	557,916
1232	484	0.232	1173	272	2.8	1.1	2.65	495	494	558,410
1233	484	0.184	1186	218	4.2	1.3	2.65	495	494	558,904
1234	484	0.241	1138	274	5.6	1.3	2.65	495	494	559,398
1235	484	0.169	1128	191	-5.6	1.3	2.65	495	494	559,892
1236	484	0.265	1164	308	1.4	1.4	2.65	495	494	560,386
1237	484	0.206	1171	241	0	8.0	2.65	495	494	560,880
1238	484	0.104	1178	122	0	1.2	2.65	495	494	561,374
1239	484	0.093	1175	109	1.4	1.3	2.65	495	494	561,868
1240	484	0.098	1241	121	0	1.3	2.65	495	494	562,362
1241	484	0.131	1245	163	0	1.2	2.65	495	494	562,856
1242	484	0.259	1158	300	1.4	8.0	2.65	495	494	563,350
1243	484	0.146	1173	171	1.4	1.3	2.65	495	494	563,844
1244	484	0.221	1157	256	1.4	1.2	2.65	495	494	564,338
1245	484	0.128	1191	152	1.4	1.2	2.65	495	494	564,832
1246	484	0.121	1202	145	2.8	3.8	2.65	495	494	565,326
1247	484	0.149	1183	176	2.8	1.3	2.65	495	494	565,820
1248	484	0.134	1203	161	2.8	1.2	2.65	495	494	566,314
1249	484	0.252	1153	291	2.8	1.2	2.65	495	494	566,808
1250	484	0.137	1197	164	2.8	2.6	2.65	495	494	567,302
1251	484	0.262	1160	304	2.8	1.3	2.65	495	494	567,796
1252	484	0.212	1153	244	2.8	1.2	2.65	495	494	568,290
1253	447	0.165	1195	197	1.4	2.0	2.65	495	494	568,784
1254	447	0.140	1228	172	1.4	1.2	2.64	495	494	569,278
1255	447	0.135	1227	166	1.4	1.3	2.64	495	494	569,772
1256	447	0.173	1222	212	1.4	1.2	2.64	495	494	570,266
1257	447	0.165	1231	203	0	1.2	2.64	495	494	570,760
1258	447	0.091	1247	114	0	1.3	2.64	495	494	571,254
1259	447	0.063	1273	80	0	1.2	2.64	495	494	571,748
1260	447	0.061	1260	77	0	1.1	2.64	495	494	572,242
1261	447	0.142	1229	174	1.4	1.2	2.64	495	494	572,736
1262	447	0.205	1225	251	0	1.2	2.64	495	494	573,230
1263	447	0.192	1220	234	0	1.2	2.63	495	494	573,724
1264	447	0.152	1236	188	0	1.2	2.63	495	494	574,218
1265	447	0.139	1247	173	0	2.5	2.63	495	494	574,712

1266	447	0.254	1205	306	0	2.6	2.63	495	494	575,206
1267	447	0.193	1210	234	0	1.2	2.63	495	494	575,700
1268	447	0.239	1207	288	0	2.6	2.63	495	494	576,194
1269	447	0.214	1212	259	0	1.2	2.63	495	494	576,688
1270	447	0.261	1178	307	1.4	6.6	2.63	495	494	577,182
1271	447	0.187	1241	232	0	1.1	2.63	495	494	577,676
1272	417	0.162	1172	190	1.4	2.5	2.63	495	494	578,170
1273	417	0.203	1195	243	0	3.1	2.63	495	494	578,664
1274	417	0.261	1182	309	-1.4	4.6	2.63	495	494	579,158
1275	406	0.266	1152	307	1.4	2.6	2.63	495	494	579,652
1276	484	0.212	1132	240	1.4	2.6	2.63	495	494	580,146
1277	484	0.234	1161	272	0	1.2	2.63	495	494	580,640
1278	447	0.175	1150	201	4.2	6.5	2.64	495	494	581,134
1279	447	0.179	1151	206	2.8	5.7	2.64	495	494	581,628
1280	447	0.133	1185	158	2.8	2.5	2.64	495	494	582,122
1281	447	0.186	1181	220	2.8	1.1	2.64	495	494	582,616
1282	447	0.182	1185	216	1.4	1.1	2.64	495	494	583,110
1283	447	0.215	1163	250	2.8	1.2	2.64	495	494	583,604
1284	447	0.210	1151	242	1.4	1.2	2.63	495	494	584,098
1285	447	0.158	1218	193	1.4	1.2	2.63	495	494	584,592
1286	447	0.211	1194	252	1.4	1.2	2.63	495	494	585,086
1287	447	0.130	1248	162	1.4	1.2	2.63	495	494	585,580
1288	447	0.120	1210	145	1.4	1.2	2.63	495	494	586,074
1289	407	0.247	1160	287	4.2	5.9	2.63	495	494	586,568
1290	407	0.249	1160	289	5.6	2.6	2.63	495	494	587,062
1291	447	0.162	1213	197	1.4	1.1	2.63	495	494	587,556
1292	447	0.172	1237	213	1.4	1.2	2.63	495	494	588,050
1293	448	0.168	1226	206	2.8	1.2	2.63	495	494	588,544
1294	448	0.211	1198	253	1.4	1.2	2.63	495	494	589,038
1295	448	0.094	1260	119	1.4	1.2	2.63	495	494	589,532
1296	448	0.115	1233	142	1.4	1.1	2.63	495	494	590,026
1297	448	0.137	1218	167	1.4	1.1	2.62	495	494	590,520
1298	448	0.068	1266	86	1.4	1.2	2.62	495	494	591,014
1299	448	0.066	1246	82	1.4	1.3	2.62	495	494	591,508
1300	448	0.068	1260	86	1.4	1.2	2.62	495	494	592,002
1301	448	0.077	1253	97	1.4	1.1	2.62	495	494	592,496
1302	448	0.116	1238	144	1.4	1.1	2.62	495	494	592,990
1303	448	0.241	1197	288	1.4	2.5	2.62	495	494	593,484
1304	448	0.263	1192	314	1.4	1.2	2.62	495	494	593,978
1305	448	0.190	1213	231	0	1.2	2.62	495	494	594,472
1306	448	0.254	1215	309	0	1.2	2.62	495	494	594,966
1307	448	0.183	1244	228	0	1.2	2.61	495	494	595,460
1308	448	0.206	1231	254	0	1.2	2.61	495	494	595,954
1309	448	0.088	1276	112	0	1.1	2.61	495	494	596,448
1310	448	0.278	1206	335	0	1.2	2.61	495	494	596,942
1311	448	0.168	1192	200	-1.4	7.6	2.61	495	494	597,436
1312	448	0.218	1177	256	-1.4	1.1	2.61	495	494	597,930
1313	448	0.258	1146	296	1.4	1.3	2.61	495	494	598,424
1314	448	0.143	1161	166	1.4	2.5	2.61	495	494	598,918
1315	448	0.148	1177	174	1.4	1.2	2.61	495	494	599,412
1316	448	0.214	1182	253	1.4	1.2	2.61	495	494	599,906
1317	484	0.217	1139	247	0	5.2	2.61	495	494	600,400
1318	484	0.133	1193	159	0	1.2	2.61	495	494	600,894
1319	484	0.120	1215	146	0	1.3	2.61	495	494	601,388
1320	484	0.079	1221	96	0	1.2	2.61	495	494	601,882
1321	484	0.074	1264	94	0	1.2	2.61	495	494	602,376
1322	484	0.094	1257	118	0	1.2	2.61	495	494	602,870
1323	417	0.222	1174	261	0	3.1	2.61	495	494	603,364
1324	417	0.252	1193	301	-4.2	4.0	2.61	495	494	603,858
1325	417	0.280	1198	336	-4.2	1.3	2.61	495	494	604,352
1326	417	0.231	1171	270	-1.4	1.2	2.61	495	494	604,846
1327	417	0.226	1149	260	-1.4	2.6	2.61	495	494	605,340
1328	418	0.256	1149	294	1.4	1.2	2.61	495	494	605,834
1329	418	0.187	1183	221	1.4	3.2	2.61	495	494	606,328
1330	418	0.170	1202	204	0	3.2	2.61	495	494	606,822
1331	418	0.196	1176	231	1.4	4.5	2.61	495	494	607,316
1332	417	0.210	1191	250	1.4	4.3	2.61	495	494	607,810
1333	448	0.167	1214	203	1.4	1.9	2.61	495	494	608,304
1334	448	0.208	1205	251	1.4	1.1	2.61	495	494	608,798
1335	448	0.249	1185	295	1.4	2.5	2.61	495	494	609,292
1336	448	0.277	1205	334	1.4	1.3	2.61	495	494	609,786
1337	448	0.229	1212	277	1.4	1.1	2.61	495	494	610,280
1338	447	0.205	1217	249	0	1.3	2.60	495	494	610,774
1339	447	0.140	1227	172	1.4	1.2	2.60	495	494	611,268
1340	447	0.141	1239	175	1.4	1.2	2.60	495	494	611,762

1341	447	0.249	1218	303	0	2.5	2.60	495	494	612,256
1342	447	0.175	1242	217	0	1.2	2.60	495	494	612,750
1343	447	0.195	1213	236	1.4	1.2	2.60	495	494	613,244
1344	447	0.219	1212	266	0	1.3	2.60	495	494	613,738
1345	417	0.238	1174	279	-2.8	6.4	2.60	495	494	614,232
1346	417	0.246	1199	295	0	5.9	2.60	495	494	614,726
1347	452	0.280	1170	328	1.4	8.7	2.61	495	494	615,220
1348	376	0.226	1097	248	-2.8	1.2	2.61	495	494	615,714
1349	376	0.253	1095	277	-2.8	1.2	2.61	495	494	616,208
1350	377	0.236	1104	261	0	1.2	2.61	495	494	616,702
1351	377	0.258	1083	279	0	7.8	2.61	495	494	617,196
1352	377	0.264	1099	290	0	2.5	2.61	495	494	617,690
1353	496	0.111	1193	133	1.4	1.3	2.61	497	496	618,186
1354	496	0.179	1203	215	1.4	1.2	2.61	497	496	618,682
1355	496	0.126	1213	153	1.4	1.2	2.61	497	496	619,178
1356	496	0.076	1216	93	1.4	1.2	2.61	497	496	619,674
1357	496	0.105	1205	127	1.4	1.2	2.60	497	496	620,170
1358	497	0.215	1216	262	0	6.3	2.61	497	496	620,666
1359	497	0.170	1221	207	0	1.1	2.61	497	496	621,162
1360	497	0.251	1211	304	0	1.2	2.60	497	496	621,658
1361	497	0.167	1225	205	0	1.2	2.60	497	496	622,154
1362	497	0.115	1245	143	0	1.2	2.60	497	496	622,650
1363	498	0.129	1197	155	0	2.7	2.60	499	498	623,148
1364	498	0.134	1198	161	0	1.3	2.60	499	498	623,646
1365	498	0.108	1201	130	0	1.3	2.60	499	498	624,144
1366	498	0.171	1206	206	0	1.3	2.60	499	498	624,642
1367	498	0.116	1229	143	0	1.2	2.60	499	498	625,140
1368	499	0.254	1180	300	1.4	2.5	2.60	499	498	625,638
1369	499	0.186	1178	219	1.4	1.2	2.60	499	498	626,136
1370	499	0.195	1192	233	1.4	1.2	2.60	499	498	626,634
1371	499	0.258	1205	311	0	2.5	2.60	499	498	627,132
1372	499	0.201	1170	235	1.4	1.2	2.60	499	498	627,630
1373	484	0.222	1182	262	2.8	8.5	2.60	499	498	628,128
1374	486	0.117	1213	142	-2.8	2.7	2.60	499	498	628,626
1375	485	0.225	1183	266	0	1.9	2.60	499	498	629,124
1376	496	0.179	1182	211	1.4	1.8	2.60	499	498	629,622
1377	498	0.181	1190	215	0	1.2	2.60	499	498	630,120
1378	406	0.132	1210	160	2.8	1.2	2.60	499	498	630,618
1379	406	0.056	1223	68	1.4	1.3	2.60	499	498	631,116
1380	406	0.071	1224	87	2.8	2.5	2.60	499	498	631,614
1381	406	0.201	1139	229	1.4	1.2	2.59	499	498	632,112
1382	406	0.273	1187	324	0	1.3	2.59	499	498	632,610
1383	447	0.113	1239	140	1.4	2.6	2.59	499	498	633,108
1384	447	0.119	1261	150	1.4	1.2	2.59	499	498	633,606
1385	486	0.125	1220	153	0	2.6	2.59	499	498	634,104
1386	448	0.129	1236	159	1.4	2.5	2.59	499	498	634,602
1387	448	0.099	1253	124	1.4	2.5	2.59	499	498	635,100
1388	484	0.147	1133	167	0	3.8	2.59	499	498	635,598
1389	484	0.098	1169	115	1.4	3.3	2.59	499	498	636,096
1390	484	0.199	1170	233	0	5.3	2.60	499	498	636,594
1391	484	0.114	1186	135	0	1.1	2.60	499	498	637,092
1392	484	0.141	1169	165	2.8	4.5	2.60	499	498	637,590
1393	484	0.122	1209	148	-1.4	6.4	2.60	499	498	638,088
1394	484	0.175	1163	204	1.4	1.6	2.60	499	498	638,586
1395	484	0.069	1253	87	0	12.7	2.61	499	498	639,084
1396	484	0.126	1234	156	0	12.4	2.61	499	498	639,582
1397	484	0.063	1225	77	0	3.2	2.61	499	498	640,080
1398	484	0.131	1192	156	0	3.7	2.61	499	498	640,578
1399	484	0.259	1146	297	1.4	2.6	2.61	499	498	641,076
1400	484	0.202	1179	238	-1.4	3.3	2.61	499	498	641,574
1401	484	0.193	1191	230	0	3.3	2.61	499	498	642,072
1402	484	0.191	1183	226	0	1.6	2.61	499	498	642,570
1403	484	0.136	1184	161	0	1.5	2.61	499	498	643,068
1404	484	0.215	1189	256	0	1.6	2.61	499	498	643,566
1405	484	0.098	1210	119	0	1.6	2.61	499	498	644,064
1406	484	0.090	1229	111	0	1.5	2.61	499	498	644,562
1407	484	0.111	1190	132	0	1.6	2.61	499	498	645,060
1408	484	0.221	1114	246	1.4	1.8	2.61	499	498	645,558
1409	484	0.250	1137	284	1.4	1.8	2.61	499	498	646,056
1410	484	0.133	1169	155	1.4	11.1	2.62	499	498	646,554
1411	484	0.198	1203	238	0	1.8	2.61	499	498	647,052
1412	484	0.138	1204	166	-1.4	5.1	2.62	499	498	647,550
1413	484	0.214	1183	253	0	2.5	2.62	499	498	648,048
1414	484	0.243	1193	290	0	1.3	2.62	499	498	648,546
1415	484	0.281	1180	331	0	1.3	2.61	499	498	649,044

1416	484	0.156	1235	193	0	1.3	2.61	499	498	649,542
1417	484	0.111	1255	139	0	1.3	2.61	499	498	650,040
1418	484	0.100	1205	120	0	1.3	2.61	499	498	650,538
1419	406	0.143	1176	168	1.4	4.0	2.61	499	498	651,036
1420	406	0.238	1167	278	1.4	1.2	2.61	499	498	651,534
1421	406	0.240	1197	287	-1.4	2.6	2.61	499	498	652,032
1422	406	0.247	1194	295	0	3.9	2.61	499	498	652,530
1423	406	0.066	1238	82	1.4	1.2	2.61	499	498	653,028
1424	406	0.074	1222	91	1.4	1.1	2.61	499	498	653,526
1425	406	0.103	1194	123	2.8	9.8	2.62	499	498	654,024
1426	406	0.165	1191	196	2.8	1.2	2.61	499	498	654,522
1427	406	0.115	1218	140	1.4	1.2	2.61	499	498	655,020
1428	484	0.182	1200	218	0	5.8	2.62	499	498	655,518
1429	447	0.124	1191	148	1.4	2.6	2.62	499	498	656,016
1430	447	0.214	1204	258	1.4	1.3	2.61	499	498	656,514
1431	447	0.153	1227	188	1.4	1.2	2.61	499	498	657,012
1432	447	0.157	1209	190	1.4	1.2	2.61	499	498	657,510
1433	447	0.210	1198	251	0	2.5	2.61	499	498	658,008
1434	447	0.196	1232	242	0	1.1	2.61	499	498	658,506
1435	447	0.145	1268	184	0	1.2	2.61	499	498	659,004
1436	447	0.148	1249	185	0	1.2	2.61	499	498	659,502
1437	447	0.168	1247	209	0	1.2	2.61	499	498	660,000
1438	447	0.181	1221	221	0	1.2	2.61	499	498	660,498
1439	447	0.211	1191	251	0	1.3	2.61	499	498	660,996
1440	447	0.118	1240	146	0	1.3	2.61	499	498	661,494
1441	447	0.126	1252	158	0	1.2	2.61	499	498	661,992
1442	447	0.187	1235	231	0	2.5	2.61	499	498	662,490
1443	447	0.216	1211	262	0	1.2	2.60	499	498	662,988
1444	447	0.139	1253	174	0	2.6	2.60	499	498	663,486
1445	447	0.173	1227	212	0	2.5	2.60	499	498	663,984
1446	447	0.163	1259	205	0	1.2	2.60	499	498	664,482
1447	447	0.172	1237	213	0	1.2	2.60	499	498	664,980
1448	447	0.150	1256	188	0	1.1	2.60	499	498	665,478
1449	447	0.181	1237	224	0	4.0	2.60	499	498	665,976
1450	447	0.170	1242	211	0	1.1	2.60	499	498	666,474
1451	447	0.251	1203	302	-1.4	1.3	2.60	499	498	666,972
1452	447	0.172	1215	209	0	1.2	2.60	499	498	667,470
1453	447	0.174	1250	217	0	1.1	2.60	499	498	667,968
1454	447	0.267	1219	325	0	1.2	2.60	499	498	668,466
1455	447	0.167	1253	209	0	1.2	2.60	499	498	668,964
1456	483	0.170	1150	196	0	9.7	2.60	499	498	669,462
1457	483	0.227	1122	255	-1.4	2.5	2.60	499	498	669,960
1458	483	0.238	1098	261	-2.8	2.5	2.60	499	498	670,458
1459	448	0.163	1185	193	1.4	2.5	2.60	499	498	670,956
1460	448	0.190	1207	229	1.4	1.2	2.60	499	498	671,454
1461	448	0.253	1200	304	1.4	1.3	2.60	499	498	671,952
1462	448	0.148	1200	178	1.4	3.1	2.60	499	498	672,450
1463	447	0.097	1248	121	1.4	2.5	2.60	499	498	672,948
1464	447	0.158	1212	191	1.4	2.0	2.60	499	498	673,446
1465	447	0.159	1207	192	1.4	1.2	2.60	499	498	673,944
1466	447	0.169	1229	208	1.4	1.1	2.60	499	498	674,442
1467	447	0.179	1228	220	1.4	2.5	2.60	499	498	674,940
1468	447	0.158	1209	191	1.4	1.1	2.60	499	498	675,438
1469	447	0.142	1245	177	0	2.6	2.60	499	498	675,936
1470	447	0.108	1237	134	1.4	1.2	2.59	499	498	676,434
1471	447	0.140	1257	176	0	1.2	2.59	499	498	676,932
1472	447	0.189	1246	235	0	1.2	2.59	499	498	677,430
1473	447	0.149	1226	183	1.4	1.2	2.59	499	498	677,928
1474	447	0.227	1205	274	1.4	1.2	2.59	499	498	678,426
1475	447	0.203	1226	249	0	2.4	2.59	499	498	678,924
1476	447	0.153	1267	194	0	1.2	2.59	499	498	679,422
1477	447	0.157	1258	198	0	1.2	2.59	499	498	679,920
1478	448	0.154	1222	188	1.4	2.6	2.59	499	498	680,418
1479	448	0.216	1212	262	1.4	1.1	2.59	499	498	680,916
1480	448	0.225	1201	270	1.4	1.2	2.59	499	498	681,414
1481	500	0.196	1207	237	-1.4	5.1	2.59	501	500	681,914
1482	501	0.263	1190	313	-1.4	5.0	2.59	501	500	682,414
1483	501	0.179	1194	214	1.4	1.2	2.59	501	500	682,914
1484	501	0.111	1240	138	1.4	1.2	2.59	501	500	683,414
1485	501	0.113	1232	139	1.4	1.3	2.59	501	500	683,914
1486	501	0.111	1230	137	1.4	1.2	2.59	501	500	684,414
1487	501	0.139	1207	168	1.4	1.3	2.59	501	500	684,914
1488	503	0.158	1214	192	0	2.6	2.59	503	502	685,416
1489	502	0.137	1216	167	1.4	4.0	2.59	503	502	685,918
1490	502	0.179	1219	218	0	1.2	2.59	503	502	686,420

1491	502	0.112	1210	135	1.4	1.3	2.59	503	502	686,922
1492	502	0.088	1229	108	1.4	1.3	2.58	503	502	687,424
1493	502	0.078	1253	98	0	1.2	2.58	503	502	687,926
1494	502	0.234	1117	261	2.8	1.8	2.58	503	502	688,428
1495	503	0.106	1237	131	-1.4	3.6	2.58	503	502	688,930
1496	503	0.109	1237	135	0	6.4	2.59	503	502	689,432
1497	447	0.132	1215	160	1.4	3.1	2.59	503	502	689,934
1498	447	0.162	1232	199	0	3.8	2.59	503	502	690,436
1499	447	0.146	1225	179	1.4	2.5	2.59	503	502	690,938
1500	447	0.166	1226	204	1.4	1.2	2.59	503	502	691,440
1501	447	0.213	1212	258	0	3.1	2.59	503	502	691,942
1502	406	0.188	1167	219	1.4	5.3	2.59	503	502	692,444
1503	406	0.202	1136	229	0	1.2	2.59	503	502	692,946
1504	406	0.271	1186	321	0	2.6	2.59	503	502	693,448
1505	484	0.228	1120	255	1.4	4.2	2.59	503	502	693,950
1506	504	0.112	1230	138	0	3.7	2.59	505	504	694,454
1507	505	0.075	1225	92	-5.6	4.4	2.59	505	504	694,958
1508	504	0.046	1270	59	-2.8	1.2	2.59	505	504	695,462
1509	504	0.044	1288	57	-2.8	1.2	2.59	505	504	695,966
1510	504	0.061	1284	78	-2.8	1.2	2.59	505	504	696,470
1511	504	0.071	1243	88	-4.2	1.2	2.59	505	504	696,974
1512	504	0.071	1248	88	-2.8	1.2	2.59	505	504	697,478
1513	504	0.060	1270	76	-2.8	1.1	2.58	505	504	697,982
1514	505	0.039	1294	50	-1.4	1.2	2.58	505	504	698,486
1515	505	0.074	1244	92	-2.8	1.2	2.58	505	504	698,990
1516	505	0.052	1264	66	-2.8	1.2	2.58	505	504	699,494
1517	505	0.042	1266	53	-2.8	1.3	2.58	505	504	699,998
1518	505	0.037	1286	48	-2.8	1.1	2.58	505	504	700,502
1519	505	0.041	1279	53	-2.8	1.2	2.58	505	504	701,006
1520	505	0.031	1278	39	-2.8	1.2	2.58	505	504	701,510
1521	13	0.246	1183	291	-1.4	10.2	2.58	505	504	702,014
1522	14	0.240	1155	277	7	9.4	2.59	505	504	702,518
1523	486	0.113	1232	139	-1.4	1.2	2.59	505	504	703,022
1524	486	0.171	1207	207	0	1.3	2.59	505	504	703,526
1525	486	0.144	1198	173	-1.4	1.3	2.59	505	504	704,030
1526	486	0.217	1198	260	-1.4	1.2	2.58	505	504	704,534
1527	14	0.238	1145	272	5.6	4.4	2.59	505	504	705,038
1528	14	0.220	1175	258	2.8	2.6	2.59	505	504	705,542
1529	14	0.234	1176	275	0	1.3	2.58	505	504	706,046
1530	13	0.268	1166	313	-4.2	6	2.59	505	504	706,550
1531	495	0.131	1203	158	2.8	3.2	2.59	505	504	707,054
1532	495	0.111	1194	133	4.2	1.2	2.59	505	504	707,558
1533	495	0.136	1202	164	2.8	3.8	2.59	505	504	708,062
1534	495	0.237	1167	276	4.2	1.2	2.59	505	504	708,566
1535	495	0.179	1175	210	4.2	3.8	2.59	505	504	709,070
1536	495	0.166	1190	197	4.2	1.2	2.59	505	504	709,574
1537	495	0.190	1198	228	2.8	1.3	2.59	505	504	710,078
1538	495	0.244	1161	283	4.2	1.3	2.58	505	504	710,582
1539	495	0.253	1170	296	2.8	5.2	2.59	505	504	711,086
1540	495	0.114	1219	139	2.8	6.6	2.59	505	504	711,590
1541	495	0.178	1215	216	2.8	1.2	2.59	505	504	712,094
1542	495	0.139	1169	163	4.2	1.2	2.59	505	504	712,598
1543	495	0.184	1145	211	1.4	.6.9	2.59	505	504	713,102
1544	495	0.151	1180	178	2.8	16.8	2.60	505	504	713,606
1545	484	0.261	1123	293	5.6	5.4	2.60	505	504	714,110
1546	484	0.158	1173	185	2.8	12.6	2.61	505	504	714,614
1547	406	0.208	1188	247	1.4	2.7	2.61	505	504	715,118
1548	406	0.195	1158	226	1.4	1.2	2.61	505	504	715,622
1549	406	0.109	1174	128	1.4	1.2	2.61	505	504	716,126
1550	406	0.182	1146	208	1.4	1.2	2.60	505	504	716,630
1551	406	0.048	1243	60	1.4	1.2	2.60	505	504	717,134
1552	406	0.084	1233	103	1.4	1.2	2.60	505	504	717,638
1553	406	0.048	1258	61	1.4	1.2	2.60	505	504	718,142
1554	406	0.058	1247	72	1.4	1.2	2.60	505	504	718,646
1555	484	0.233	1104	257	2.8	3.2	2.60	505	504	719,150
1556	484	0.203	1140	231	2.8	1.2	2.60	505	504	719,654
1557	484	0.129	1223	158	1.4	1.3	2.60	505	504	720,158
1558	484	0.124	1212	150	1.4	1.2	2.60	505	504	720,662
1559	484	0.228	1164	265	1.4	1.3	2.60	505	504	721,166
1560	484	0.202	1162	235	0	2.5	2.60	505	504	721,670
1561	506	0.262	1197	314	-1.4	3.2	2.60	507	506	722,176
1562	506	0.153	1231	188	0	8.2	2.60	507	506	722,682
1563	506	0.145	1258	182	0	4.4	2.60	507	506	723,188
1564	506	0.205	1174	241	-5.6	5.8	2.61	507	506	723,694
1565	506	0.138	1226	169	-4.2	1.2	2.60	507	506	724,200

1566	406	0.172	1189	205	1.4	1.2	2.60	507	506	724,706
1567	406	0.250	1169	292	1.4	1.3	2.60	507	506	725,212
1568	406	0.054	1250	67	1.4	1.2	2.60	507	506	725,718
1569	486	0.192	1205	231	0	2.6	2.60	507	506	726,224
1570	487	0.152	1174	179	-2.8	1.1	2.60	507	506	726,730
1571	406	0.214	1184	253	1.4	2.5	2.60	507	506	727,236
1572	406	0.115	1196	138	1.4	8.4	2.60	507	506	727,742
1573	406	0.068	1233	84	0	2.6	2.60	507	506	728,248
1574	406	0.059	1230	73	0	1.2	2.60	507	506	728,754
1575	406	0.172	1200	206	0	1.2	2.60	507	506	729,260
1576	406	0.088	1217	107	0	1.2	2.60	507	506	729,766
1577	406	0.072	1226	88	0	1.2	2.60	507	506	730,272
1578	406	0.144	1200	173	0	1.3	2.60	507	506	730,778
1579	407	0.207	1176	244	1.4	1.2	2.60	507	506	731,284
1580	407	0.210	1185	249	0	1.2	2.60	507	506	731,790
1581	406	0.234	1133	265	1.4	1.8	2.60	507	506	732,296
1582	406	0.260	1116	290	1.4	1.2	2.60	507	506	732,802
1583	308	0.277	1116	309	1.4	15.1	2.60	507	506	733,308
1584	309	0.267	1071	286	2.8	1.1	2.60	507	506	733,814
1585	310	0.270	1087	294	4.2	7.9	2.61	507	506	734,320
1586	311	0.221	1129	250	2.8	5.3	2.61	507	506	734,826
1587	406	0.108	1231	133	0	1.3	2.61	507	506	735,332
1588	406	0.172	1163	200	1.4	1.8	2.61	507	506	735,838
1589	406	0.079	1227	97	0	1.2	2.61	507	506	736,344
1590	406	0.097	1218	118	1.4	1.2	2.61	507	506	736,850
1591	406	0.057	1243	71	0	1.2	2.60	507	506	737,356
1592	406	0.063	1263	80	0	1.2	2.60	507	506	737,862
1593	406	0.062	1247	77	0	1.2	2.60	507	506	738,368
1594	308	0.171	1113	190	2.8	5.9	2.61	507	506	738,874
1595	508	0.162	1203	195	-1.4	1.3	2.60	509	508	739,382
1596	509	0.130	1278	166	-1.4	12.2	2.61	509	508	739,890
1597	510	0.235	1174	276	4.2	2.6	2.61	511	510	740,400
1598	510	0.155	1172	182	5.6	5.8	2.61	511	510	740,910
1599	510	0.169	1210	204	5.6	1.3	2.61	511	510	741,420
1600	510	0.172	1175	202	5.6	1.2	2.61	511	510	741,930
1601	510	0.206	1199	247	5.6	1.2	2.61	511	510	742,440
1602	510	0.141	1209	171	5.6	1.2	2.61	511	510	742,950
1603	511	0.209	1227	257	-1.4	2.5	2.61	511	510	743,460
1604	511	0.185	1231	228	-1.4	1.2	2.61	511	510	743,970
1605	511	0.148	1242	184	-1.4	1.2	2.61	511	510	744,480
1606	511	0.140	1261	176	-1.4	1.2	2.61	511	510	744,990
1607	511	0.169	1244	210	-1.4	1.2	2.61	511	510	745,500
1608	484	0.148	1158	171	1.4	25.4	2.62	511	510	746,010
1609	484	0.127	1195	152	-1.4	1.3	2.62	511	510	746,520
1610	447	0.187	1213	227	1.4	1.2	2.62	511	510	747,030
1611	447	0.169	1222	206	1.4	1.2	2.62	511	510	747,540
1612	448	0.253	1197	303	1.4	1.3	2.62	511	510	748,050
1613	448	0.276	1194	330	1.4	1.3	2.62	511	510	748,560
1614	448	0.185	1214	225	1.4	3.3	2.62	511	510	749,070
1615	448	0.222	1216	270	0	2.5	2.62	511	510	749,580
1616	448	0.254	1185	301	1.4	1.2	2.61	511	510	750,090
1617	448	0.147	1246	183	0	1.1	2.61	511	510	750,600
1618	448	0.159	1249	199	0	1.3	2.61	511	510	751,110
1619	447	0.212	1190	252	2.8	1.2	2.61	511	510	751,620
1620	447	0.217	1201	261	0	1.2	2.61	511	510	752,130
1621	447	0.176	1241	219	0	1.1	2.61	511	510	752,640
1622	447	0.158	1239	196	0	1.1	2.61	511	510	753,150
1623	447	0.279	1186	331	0	1.2	2.61	511	510	753,660
1624	447	0.166	1226	203	1.4	1.2	2.61	511	510	754,170
1625	447	0.192	1231	236	1.4	1.2	2.61	511	510	754,680
1626	447	0.207	1198	248	1.4	1.1	2.61	511	510	755,190
1627	447	0.180	1199	216	1.4	1.2	2.60	511	510	755,700
1628	447	0.186	1209	225	1.4	1.2	2.60	511	510	756,210
1629	447	0.145	1217	176	1.4	1.1	2.60	511	510	756,720
1630	448	0.238	1201	286	1.4	1.2	2.60	511	510	757,230
1631	448	0.155	1222	189	1.4	1.2	2.60	511	510	757,740
1632	448	0.212	1212	257	0	1.1	2.60	511	510	758,250
1633	448	0.082	1241	102	0	1.3	2.60	511	510	758,760
1634	448	0.247	1188	293	1.4	1.1	2.60	511	510	759,270
1635	448	0.233	1211	282	1.4	1.2	2.60	511	510	759,780
1636	448	0.162	1252	203	1.4	2.6	2.60	511	510	760,290
1637	448	0.243	1195	290	1.4	2.5	2.60	511	510	760,800
1638	448	0.269	1177	317	1.4	4	2.60	511	510	761,310
1639	448	0.223	1214	271	1.4	2.5	2.60	511	510	761,820
1640	448	0.186	1231	229	1.4	1.2	2.60	511	510	762,330

1641	448	0.246	1181	291	1.4	1.1	2.60	511	510	762,840
1642	448	0.161	1220	197	1.4	2.5	2.60	511	510	763,350
1643	448	0.175	1222	214	1.4	1.1	2.60	511	510	763,860
1644	448	0.173	1215	210	1.4	1.2	2.60	511	510	764,370
1645	448	0.172	1201	207	1.4	2.5	2.59	511	510	764,880
1646	448	0.148	1200	178	1.4	1.2	2.59	511	510	765,390
1647	448	0.187	1215	227	1.4	1.1	2.59	511	510	765,900
1648	448	0.241	1218	293	0	1.3	2.59	511	510	766,410
1649	448	0.246	1193	293	1.4	2.5	2.59	511	510	766,920
1650	448	0.234	1175	275	1.4	1.2	2.59	511	510	767,430
1651	448	0.119	1236	147	1.4	2.5	2.59	511	510	767,940
1652	448	0.143	1242	178	0	1.2	2.59	511	510	768,450
1653	448	0.206	1203	248	1.4	1.2	2.59	511	510	768,960
1654	448	0.265	1175	311	1.4	1.2	2.59	511	510	769,470
1655	448	0.214	1196	256	1.4	3.8	2.59	511	510	769,980
1656	448	0.225	1214	273	1.4	1.2	2.59	511	510	770,490
1657	448	0.156	1247	194	0	2.4	2.59	511	510	771,000
1658	448	0.195	1199	234	1.4	2.5	2.59	511	510	771,510
1659	448	0.199	1223	243	1.4	1.1	2.59	511	510	772,020
1660	448	0.164	1191	195	1.4	1.3	2.59	511	510	772,530
1661	448	0.264	1180	312	1.4	5	2.59	511	510	773,040
1662	448	0.253	1218	308	1.4	1.2	2.59	511	510	773,550
1663	448	0.254	1189	302	1.4	1.2	2.59	511	510	774,060
1664	447	0.183	1240	227	0	2.6	2.59	511	510	774,570
1665	447	0.174	1197	208	1.4	1.2	2.59	511	510	775,080
1666	447	0.174	1240	216	0	1.1	2.59	511	510	775,590
1667	447	0.179	1232	220	0	2.5	2.59	511	510	776,100
1668	447	0.124	1239	154	0	1.3	2.58	511	510	776,610
1669	447	0.248	1209	300	0	1.2	2.58	511	510	777,120
1670	447	0.224	1213	272	0	1.2	2.58	511	510	777,630
1671	447	0.208	1234	257	0	2.5	2.58	511	510	778,140
1672	447	0.176	1224	215	0	1.2	2.58	511	510	778,650
1673	447	0.188	1194	224	1.4	1.3	2.58	511	510	779,160
1674	447	0.120	1250	150	0	1.2	2.58	511	510	779,670
1675	447	0.133	1260	168	0	1.2	2.58	511	510	780,180
1676	447	0.144	1241	179	0	1.2	2.58	511	510	780,690
1677	447	0.135	1244	168	0	1.1	2.58	511	510	781,200
1678	447	0.172	1247	215	0	1.2	2.58	511	510	781,710
1679	447	0.131	1256	165	0	1.2	2.58	511	510	782,220
1680	447	0.084	1246	105	0	1.3	2.58	511	510	782,730
1681	447	0.144	1240	179	0	2.6	2.58	511	510	783,240
1682	447	0.123	1254	154	0	1.2	2.57	511	510	783,750
1683	447	0.116	1255	146	0	1.2	2.57	511	510	784,260
1684	447	0.161	1245	201	0	1.2	2.57	511	510	784,770
1685	447	0.132	1246	164	0	1.1	2.57	511	510	785,280
1686	447	0.192	1204	231	1.4	1.1	2.57	511	510	785,790
1687	447	0.115	1236	142	1.4	1.2	2.57	511	510	786,300
1688	447	0.082	1228	101	1.4	1.2	2.57	511	510	786,810
1689	447	0.118	1251	148	0	1.3	2.57	511	510	787,320
1690	484	0.211	1178	248	1.4	2.6	2.57	511	510	787,830
1691	484	0.232	1145	266	0	3.9	2.57	511	510	788,340
1692	447	0.152	1213	184	1.4	2.5	2.57	511	510	788,850
1693	486	0.211	1178	248	-2.8	1.2	2.57	511	510	789,360
1694	512	0.129	1227	158	-4.2	2.7	2.57	513	512	789,872
1695	513	0.209	1167	244	0	2.6	2.57	513	512	790,384
1696	452	0.219	1191	261	0	7.2	2.57	513	512	790,896
1697	453	0.270	1124	303	-2.8	2.5	2.57	513	512	791,408
1698	453	0.247	1155	285	0	3.2	2.57	513	512	791,920
1699	452	0.262	1142	299	1.4	8	2.57	513	512	792,432
1700	447	0.277	1151	319	0	7	2.58	513	512	792,944
1701	447	0.211	1051	222	1.4	1.2	2.58	513	512	793,456
1702	447	0.174	1198	209	2.8	4	2.58	513	512	793,968
1703	447	0.183	1206	221	2.8	1.2	2.58	513	512	794,480
1704	448	0.187	1190	222	1.4	2.6	2.58	513	512	794,992
1705	448	0.233	1185	276	2.8	1.2	2.58	513	512	795,504
1706	406	0.118	1222	144	0	2.6	2.58	513	512	796,016
1707	514	0.213	1036	221	-1.4	1.2	2.58	513	512	796,528
1708	540	0.248	1044	259	1.4	2.5	2.58	513	512	797,040
1709	541	0.259	1141	296	0	1.1	2.57	513	512	797,552
1710	541	0.139	1184	164	0	1.1	2.57	513	512	798,064
1711	541	0.167	1181	197	0	1.2	2.57	513	512	798,576
1712	541	0.125	1185	148	0	1.2	2.57	513	512	799,088
1713	541	0.160	1143	183	0	1.2	2.57	513	512	799,600
1714	542	0.223	1185	264	0	3.8	2.57	513	512	800,112
1715	542	0.210	1227	258	0	1.3	2.57	513	512	800,624

1716	542	0.202	1194	241	0	1.2	2.57	513	512	801,136
1717	542	0.235	1177	277	0	1.2	2.57	513	512	801,648
1718	542	0.215	1173	252	0	1.2	2.57	513	512	802,160
1719	542	0.144	1225	176	0	1.2	2.57	513	512	802,672
1720	542	0.190	1203	229	0	1.2	2.57	513	512	803,184
1721	544	0.129	1161	150	0	1.2	2.57	513	512	803,696
1722	514	0.228	1044	238	-1.4	9.1	2.57	565	564	804,260
1723	514	0.245	1041	255	0	1.1	2.57	565	564	804,824
1724	515	0.150	1125	169	0	1.1	2.57	565	564	805,388
1725	515	0.151	1132	171	0	1.2	2.57	565	564	805,952
1726	515	0.162	1103	179	0	1.1	2.57	565	564	806,516
1727	516	0.179	1161	208	-1.4	1.3	2.57	565	564	807,080
1728	516	0.105	1216	128	1.4	2.5	2.57	565	564	807,644
1729	516	0.161	1208	194	0	1.2	2.57	565	564	808,208
1730	516	0.132	1216	160	0	1.3	2.56	565	564	808,772
1731	516	0.153	1201	184	0	1.2	2.56	565	564	809,336
1732	516	0.155	1185	184	0	1.3	2.56	565	564	809,900
1733	516	0.219	1178	258	-1.4	1.3	2.56	565	564	810,464
1734	517	0.269	1155	311	1.4	1.2	2.56	565	564	811,028
1735	517	0.032	1300	41	0	2.5	2.56	565	564	811,592
1736	517	0.037	1283	47	0	1.1	2.56	565	564	812,156
1737	517	0.118	1222	144	0	2.4	2.56	565	564	812,720
1738	517	0.130	1221	159	0	5.2	2.56	565	564	813,284
1739	517	0.191	1165	222	0	6.5	2.56	565	564	813,848
1740	518	0.280	1152	323	1.4	8.9	2.57	565	564	814,412
1741	518	0.251	1166	293	0	1.2	2.57	565	564	814,976
1742	518	0.239	1160	277	0	1.1	2.57	565	564	815,540
1743	518	0.187	1171	219	0	1.2	2.57	565	564	816,104
1744	518	0.169	1166	197	0	1.2	2.56	565	564	816,668
1745	518	0.238	1144	272	1.4	1.2	2.56	565	564	817,232
1746	518	0.230	1162	267	1.4	1.2	2.56	565	564	817,796
1747	518	0.140	1176	165	0	1.2	2.56	565	564	818,360
1748	519	0.176	1135	200	0	2.5	2.56	565	564	818,924
1749	519	0.138	1127	156	0	1.2	2.56	565	564	819,488
1750	519	0.154	1091	168	-1.4	1.2	2.56	565	564	820,052
1751	519	0.185	1128	209	0	1.1	2.56	565	564	820,616
1752	519	0.156	1139	178	0	2.5	2.56	565	564	821,180
1753	519	0.130	1153	150	0	1.1	2.56	565	564	821,744
1754	519	0.131	1151	151	0	1.2	2.56	565	564	822,308
1755	519	0.139	1137	158	-1.4	1.1	2.56	565	564	822,872
1756	519	0.138	1141	157	0	1.2	2.56	565	564	823,436
1757	520	0.199	1139	227	0	1.2	2.56	565	564	824,000
1758	520	0.161	1113	179	0	1.1	2.55	565	564	824,564
1759	520	0.145	1149	167	0	1.2	2.55	565	564	825,128
1760	520	0.185	1125	208	0	2.6	2.55	565	564	825,692
1761	520	0.145	1144	166	0	1.1	2.55	565	564	826,256
1762	520	0.194	1104	214	1.4	1.2	2.55	565	564	826,820
1763	521	0.137	1134	155	0	1.2	2.55	565	564	827,384
1764	521	0.189	1114	211	0	1.1	2.55	565	564	827,948
1765	521	0.113	1137	129	0	1.1	2.55	565	564	828,512
1766	521	0.133	1109	148	0	1.2	2.55	565	564	829,076
1767	521	0.144	1119	161	0	1.1	2.55	565	564	829,640
1768	520	0.197	1110	219	1.4	1.1	2.55	565	564	830,204
1769	521	0.138	1127	155	0	1.2	2.55	565	564	830,768
1770	521	0.102	1113	114	0	1.2	2.55	565	564	831,332
1771	521	0.117	1113	130	0	1.2	2.55	565	564	831,896
1772	521	0.163	1083	177	0	1.1	2.54	565	564	832,460
1773	521	0.134	1120	150	0	2.5	2.54	565	564	833,024
1774	521	0.130	1105	144	0	1.1	2.54	565	564	833,588
1775	522	0.193	1063	205	0	1.1	2.54	565	564	834,152
1776	522	0.113	1143	129	0	1.2	2.54	565	564	834,716
1777	522	0.133	1117	149	0	1.1	2.54	565	564	835,280
1778	522	0.174	1077	187	1.4	9.1	2.55	565	564	835,844
1779	522	0.183	1095	200	0	1.1	2.54	565	564	836,408
1780	523	0.184	1181	217	1.4	2.4	2.54	565	564	836,972
1781	523	0.216	1147	248	-1.4	1.1	2.54	565	564	837,536
1782	523	0.036	1267	46	0	1.2	2.54	565	564	838,100
1783	523	0.039	1260	49	0	1.1	2.54	565	564	838,664
1784	523	0.203	1229	250	0	1.1	2.54	565	564	839,228
1785	524	0.096	1141	110	0	1.1	2.54	565	564	839,792
1786	524	0.118	1154	136	0	1.2	2.54	565	564	840,356
1787	524	0.175	1141	200	-1.4	2.6	2.54	565	564	840,920
1788	524	0.146	1132	165	-1.4	1.2	2.54	565	564	841,484
1789	524	0.170	1153	196	0	1.2	2.54	565	564	842,048
1790	524	0.213	1134	241	-1.4	1.2	2.54	565	564	842,612

1791	525	0.153	1136	174	0	3.1	2.54	565	564	843,176
1792	525	0.178	1134	202	0	1.2	2.54	565	564	843,740
1793	525	0.158	1163	184	0	1.1	2.54	565	564	844,304
1794	525	0.132	1144	151	0	1.2	2.54	565	564	844,868
1795	525	0.259	1100	285	1.4	3.8	2.54	565	564	845,432
1796	526	0.200	1131	226	0	3.9	2.54	565	564	845,996
1797	526	0.216	1095	237	0	1.2	2.54	565	564	846,560
1798	526	0.175	1107	194	0	6.5	2.54	565	564	847,124
1799	526	0.169	1089	184	0	1.1	2.54	565	564	847,688
1800	526	0.145	1173	170	0	1.2	2.54	565	564	848,252
1801	527	0.158	1105	175	0	1.2	2.54	565	564	848,816
1802	527	0.238	1098	261	0	1.2	2.54	565	564	849,380
1803	527	0.157	1099	173	0	1.2	2.53	565	564	849,944
1804	527	0.150	1103	166	0	1.2	2.53	565	564	850,508
1805	527	0.222	1077	239	0	1.2	2.53	565	564	851,072
1806	527	0.139	1098	153	0	1.2	2.53	565	564	851,636
1807	528	0.191	1112	212	0	2.5	2.53	565	564	852,200
1808	529	0.124	1157	143	0	1.2	2.53	565	564	852,764
1809	527	0.185	1097	203	0	1.2	2.53	565	564	853,328
1810	527	0.157	1124	177	0	1.2	2.53	565	564	853,892
1811	527	0.177	1116	197	0	1.1	2.53	565	564	854,456
1812	527	0.126	1131	142	0	1.2	2.53	565	564	855,020
1813	528	0.216	1100	238	0	1.1	2.53	565	564	855,584
1814	528	0.189	1104	209	0	1.2	2.53	565	564	856,148
1815	528	0.144	1112	160	0	1.2	2.53	565	564	856,712
1816	528	0.237	1101	261	0	1.2	2.53	565	564	857,276
1817	529	0.219	1050	230	1.4	1.2	2.52	565	564	857,840
1818	529	0.202	1112	225	-1.4	1.1	2.52	565	564	858,404
1819	529	0.205	1116	229	1.4	1.2	2.52	565	564	858,968
1820	529	0.216	1141	246	0	1.2	2.52	565	564	859,532
1821	529	0.131	1136	149	1.4	1.1	2.52	565	564	860,096
1822	530	0.157	1092	171	0	1.1	2.52	565	564	860,660
1823	530	0.067	1141	77	0	1.1	2.52	565	564	861,224
1824	530	0.089	1122	100	0	1.2	2.52	565	564	861,788
1825	530	0.122	1086	132	0	1.1	2.52	565	564	862,352
1826	530	0.168	1097	184	0	1.2	2.52	565	564	862,916
1827	531	0.090	1114	100	0	2.5	2.52	565	564	863,480
1828	531	0.085	1100	94	0	1.2	2.52	565	564	864,044
1829	531	0.151	1099	166	0	1.2	2.52	565	564	864,608
1830	531	0.137	1115	153	0	1.2	2.52	565	564	865,172
1831	531	0.202	1101	222	-1.4	1.2	2.52	565	564	865,736
1832	532	0.153	1167	179	0	7.8	2.52	565	564	866,300
1833	532	0.223	1141	254	-1.4	1.2	2.52	565	564	866,864
1834	532	0.158	1162	184	-1.4	1.1	2.52	565	564	867,428
1835	532	0.157	1165	183	0	1.1	2.52	565	564	867,992
1836	532	0.149	1171	175	-1.4	1.2	2.52	565	564	868,556
1837	532	0.089	1174	104	0	6.3	2.52	565	564	869,120
1838	533	0.121	1193	144	0	3.7	2.52	565	564	869,684
1839	533	0.132	1156	153	0	1.2	2.52	565	564	870,248
1840	533	0.123	1139	140	1.4	1.2	2.52	565	564	870,812
1841	533	0.126	1187	150	0	1.2	2.52	565	564	871,376
1842	533	0.118	1185	140	0	1.2	2.51	565	564	871,940
1843	534	0.097	1156	112	0	1.1	2.51	565	564	872,504
1844	534	0.233	1091	254	0	1.1	2.51	565	564	873,068
1845	534	0.127	1154	147	0	1.1	2.51	565	564	873,632
1846	534	0.166	1101	183	0	1.2	2.51	565	564	874,196
1847	534	0.175	1122	196	0	1.1	2.51	565	564	874,760
1848	535	0.191	1076	205	1.4	1.1	2.51	565	564	875,324
1849	535	0.215	1109	238	1.4	1.2	2.51	565	564	875,888
1850	535	0.196	1141	224	0	1.2	2.51	565	564	876,452
1851	535	0.169	1101	186	1.4	1.2	2.51	565	564	877,016
1852	535	0.177	1099	195	0	1.2	2.51	565	564	877,580
1853	535	0.129	1123	145	0	1.2	2.51	565	564	878,144
1854	537	0.223	1147	256	0	3.9	2.51	565	564	878,708
1855	537	0.139	1188	165	0	1.1	2.51	565	564	879,272
1856	537	0.091	1223	111	0	1.2	2.51	565	564	879,836
1857	537	0.160	1163	186	0	1.2	2.51	565	564	880,400
1858	537	0.142	1159	165	0	1.1	2.50	565	564	880,964
1859	537	0.117	1168	137	0	1.1	2.50	565	564	881,528
1860	538	0.167	1158	193	0	1.1	2.50	565	564	882,092
1861	538	0.140	1188	166	0	1.2	2.50	565	564	882,656
1862	538	0.192	1141	219	0	1.1	2.50	565	564	883,220
1863	538	0.152	1177	179	0	1.2	2.50	565	564	883,784
1864	538	0.135	1163	157	0	1.2	2.50	565	564	884,348
1865	539	0.150	1059	159	0	2.4	2.50	565	564	884,912

1866	539	0.137	1109	152	0	1.1	2.50	565	564	885,476
1867	539	0.035	1156	40	0	1.1	2.50	565	564	886,040
1868	539	0.118	1126	133	0	1.1	2.50	565	564	886,604
1869	539	0.090	1140	103	0	1.1	2.50	565	564	887,168
1870	539	0.157	1100	173	0	1.1	2.50	565	564	887,732
1871	539	0.136	1083	147	0	1.2	2.50	565	564	888,296
1872	540	0.257	1058	272	0	1.2	2.50	565	564	888,860
1873	540	0.269	1060	285	0	1.2	2.49	565	564	889,424
1874	540	0.211	1081	228	0	1.2	2.49	565	564	889,988
1875	540	0.142	1102	157	0	1.2	2.49	565	564	890,552
1876	540	0.205	1105	227	0	1.1	2.49	565	564	891,116
1877	540	0.196	1078	211	0	2.5	2.49	565	564	891,680
1878	541	0.248	1125	279	1.4	1.2	2.49	565	564	892,244
1879	541	0.189	1150	217	0	1.2	2.49	565	564	892,808
1880	541	0.235	1136	267	0	2.5	2.49	565	564	893,372
1881	541	0.239	1162	278	0	1.2	2.49	565	564	893,936
1882	541	0.123	1180	145	0	1.2	2.49	565	564	894,500
1883	541	0.143	1185	169	0	1.2	2.49	565	564	895,064
1884	543	0.214	1149	246	-1.4	1.2	2.49	565	564	895,628
1885	543	0.140	1140	160	0	1.2	2.49	565	564	896,192
1886	544	0.166	1162	193	0	1.2	2.49	565	564	896,756
1887	544	0.071	1202	85	0	1.1	2.49	565	564	897,320
1888	544	0.119	1165	139	0	1.2	2.49	565	564	897,884
1889	544	0.276	1119	309	1.4	8	2.49	565	564	898,448
1890	545	0.167	1195	199	0	1.2	2.49	565	564	899,012
1891	545	0.114	1222	139	0	1.1	2.49	565	564	899,576
1892	545	0.184	1187	219	0	1.2	2.49	565	564	900,140
1893	545	0.204	1182	241	1.4	1.2	2.49	565	564	900,704
1894	545	0.179	1187	212	0	1.2	2.48	565	564	901,268
1895	545	0.104	1217	127	0	1.2	2.48	565	564	901,832
1896	546	0.218	1137	248	0	1.1	2.48	565	564	902,396
1897	546	0.195	1117	218	0	1.1	2.48	565	564	902,960
1898	546	0.176	1111	196	0	1.2	2.48	565	564	903,524
1899	546	0.164	1110	182	0	1.2	2.48	565	564	904,088
1900	546	0.215	1072	231	0	1.2	2.48	565	564	904,652
1901	546	0.182	1114	203	0	1.2	2.48	565	564	905,216
1902	546	0.113	1155	131	0	2.5	2.48	565	564	905,780
1903	547	0.193	1215	234	0	1.1	2.48	565	564	906,344
1904	547	0.156	1180	184	0	1.1	2.48	565	564	906,908
1905	547	0.175	1165	204	0	1.2	2.48	565	564	907,472
1906	547	0.154	1220	188	0	1.1	2.48	565	564	908,036
1907	547	0.153	1204	184	0	1.1	2.48	565	564	908,600
1908	549	0.206	1098	226	0	1.1	2.48	565	564	909,164
1909	549	0.169	1106	187	0	2.6	2.48	565	564	909,728
1910	549	0.223	1114	248	0	1.1	2.48	565	564	910,292
1911	549	0.253	1088	275	0	1.1	2.47	565	564	910,856
1912	549	0.268	1077	289	-1.4	2.6	2.47	565	564	911,420
1913	549	0.245	1068	262	-1.4	1.2	2.47	565	564	911,984
1914	549	0.249	1058	263	-1.4	4	2.47	565	564	912,548
1915	550	0.250	961	240	0	1.1	2.47	565	564	913,112
1916	550	0.202	1005	203	0	1.2	2.47	565	564	913,676
1917	550	0.253	914	231	0	3.8	2.47	565	564	914,240
1918	550	0.220	976	215	0	1.1	2.47	565	564	914,804
1919	551	0.174	918	160	1.4	7.8	2.48	565	564	915,368
1920	551	0.182	1014	185	0	7.7	2.48	565	564	915,932
1921	551	0.221	996	220	0	1.2	2.48	565	564	916,496
1922	551	0.076	1029	78	0	1.2	2.48	565	564	917,060
1923	551	0.247	983	243	0	2.5	2.48	565	564	917,624
1924	552	0.103	1119	115	0	3.8	2.48	565	564	918,188
1925	552	0.197	1101	217	0	2.4	2.48	565	564	918,752
1926	552	0.054	1157	63	0	1.1	2.48	565	564	919,316
1927	552	0.064	1163	74	0	1.2	2.48	565	564	919,880
1928	552	0.078	1134	89	0	1.1	2.48	565	564	920,444
1929	552	0.207	1077	223	0	1.1	2.48	565	564	921,008
1930	553	0.197	1089	214	0	1.2	2.47	565	564	921,572
1931	553	0.250	1070	268	-1.4	1.1	2.47	565	564	922,136
1932	553	0.183	1113	204	0	1.2	2.47	565	564	922,700
1933	553	0.201	1137	229	0	1.3	2.47	565	564	923,264
1934	553	0.118	1137	134	0	1.2	2.47	565	564	923,828
1935	554	0.236	1073	253	1.4	1.2	2.47	565	564	924,392
1936	554	0.216	1081	233	0	3.3	2.47	565	564	924,956
1937	554	0.233	1063	248	0	2.5	2.47	565	564	925,520
1938	554	0.213	1082	231	0	1.2	2.47	565	564	926,084
1939	554	0.228	1053	240	0	1.2	2.47	565	564	926,648
1940	554	0.250	1071	268	1.4	1.2	2.47	565	564	927,212

1941	555	0.204	1109	226	-1.4	1.1	2.47	565	564	927,776
1942	555	0.237	1093	259	-1.4	1.2	2.47	565	564	928,340
1943	555	0.239	1096	262	0	1.2	2.47	565	564	928,904
1944	555	0.152	1095	166	0	1.1	2.47	565	564	929,468
1945	556	0.151	1241	188	0	1	2.47	565	564	930,032
1946	554	0.274	1082	296	0	1.4	2.47	565	564	930,596
1947	553	0.261	1122	293	0	1.1	2.46	565	564	931,160
1948	554	0.202	1106	223	0	2.5	2.46	565	564	931,724
1949	554	0.232	1071	248	0	2.5	2.47	565	564	932,288
1950	555	0.225	1115	251	0	1.1	2.46	565	564	932,852
1951	556	0.156	1221	191	0	1.1	2.46	565	564	933,416
1952	556	0.280	1229	344	0	1.1	2.46	565	564	933,980
1953	556	0.193	1261	244	0	1.1	2.46	565	564	934,544
1954	556	0.091	1217	111	0	3.8	2.46	565	564	935,108
1955	556	0.197	1216	239	0	1.1	2.46	565	564	935,672
1956	556	0.240	1221	293	0	1.1	2.46	565	564	936,236
1957	557	0.111	1136	126	0	1.2	2.46	565	564	936,800
1958	558	0.243	1155	281	-1.4	1.1	2.46	565	564	937,364
1959	558	0.241	1160	280	-1.4	1.2	2.46	565	564	937,928
1960	558	0.238	1152	274	-1.4	1.1	2.46	565	564	938,492
1961	558	0.140	1161	162	0	1.2	2.46	565	564	939,056
1962	559	0.186	1165	217	0	1.1	2.46	565	564	939,620
1963	559	0.086	1204	104	0	2.5	2.46	565	564	940,184
1964	560	0.171	1031	176	0	6.4	2.46	565	564	940,748
1965	560	0.168	1008	169	0	1.1	2.46	565	564	941,312
1966	560	0.102	982	100	0	1.1	2.46	565	564	941,876
1967	560	0.102	1071	109	0	1.1	2.46	565	564	942,440
1968	560	0.076	1084	82	0	1.1	2.46	565	564	943,004
1969	560	0.145	1053	153	0	2.4	2.46	565	564	943,568
1970	561	0.175	1038	182	0	1	2.46	565	564	944,132
1971	562	0.245	1079	264	-1.4	2.6	2.46	565	564	944,696
1972	562	0.266	1083	288	1.4	1.3	2.46	565	564	945,260
1973	562	0.217	1106	240	0	1.2	2.45	565	564	945,824
1974	562	0.253	1073	271	0	1.1	2.45	565	564	946,388
1975	562	0.257	1087	279	1.4	1.1	2.45	565	564	946,952
1976	562	0.243	1089	265	0	1.2	2.45	565	564	947,516
1977	563	0.273	1119	306	-1.4	1.3	2.45	565	564	948,080
1978	563	0.258	1126	290	-1.4	1.2	2.45	565	564	948,644
1979	563	0.250	1083	271	-1.4	1.1	2.45	565	564	949,208
1980	563	0.225	1118	252	-1.4	3.8	2.45	565	564	949,772
1981	563	0.093	1160	108	0	1.1	2.45	565	564	950,336
1982	563	0.159	1149	183	1.4	1.2	2.45	565	564	950,900
1983	563	0.154	1143	176	0	2.5	2.45	565	564	951,464
1984	564	0.064	1192	76	0	1.1	2.45	565	564	952,028
1985	564	0.040	1220	49	0	1.1	2.45	565	564	952,592
1986	564	0.054	1234	67	0	1.1	2.45	565	564	953,156
1987	564	0.070	1205	84	0	1.1	2.45	565	564	953,720
1988	564	0.065	1177	77	0	1.1	2.45	565	564	954,284
1989	564	0.237	1112	264	0	1.1	2.45	565	564	954,848
1990	564	0.148	1154	171	1.4	2.4	2.45	565	564	955,412
1991	565	0.063	1181	74	0	1.1	2.45	565	564	955,976
1992	565	0.050	1159	58	0	1.2	2.44	565	564	956,540
1993	565	0.076	1159	88	0	1.1	2.44	565	564	957,104
1994	565	0.263	1082	285	-1.4	1.2	2.44	565	564	957,668

APPENDIX C

IRISCAN FUNCTIONAL DESCRIPTION

C.1 TECHNOLOGY FUNDAMENTALS

IriScan biometric identification technology is based two fundamental facts. First, the iris is a measurably unique organ, and second, the iris is a stable, unchanging organ.

The iris is the colored portion of the eye on the visible surface of the eye surrounding the pupil, and surrounded by the white portion (sclera) of the eye. The iris is protected by the clear cornea and aqueous humor. The iris is rich in features which can be used to quantitatively and positively distinguish one iris from another. These include collagenous fibers and filaments, crypts, contraction furrows, corona, freckles, pits, rings, striations, and serpentine vasculature. (Color is an additional feature which IriScan does not use.)

The random pattern of these features results from chaotic morphogenesis at the time of conception. The uniqueness of these random patterns has long been recognized by experts in the field. Measuring the iris features for length, width, angle of deflection and location enables a statistical analysis with over 400 degrees of freedom. Since this is about six times the number available in conventional fingerprint analysis, the capability of much greater IriScan accuracy is obvious.

Eye experts also verify that the iris stabilizes by age one year, and absent injury, disease, or operation, remains constant and unchanged throughout life.

The uniqueness, stability, and easy visibility of the iris make it the ideal basis for the ultimate biometric identification technology.

C.2 THE BRASSBOARD SYSTEM

The DNA Brassboard Iris-based Proof-of-Concept System is fabricated from standard, off-the-shelf modules. The system utilizes the Intel 486DX4 microprocessor chip with 256 KB cache, 8 MB DRAM memory and 4 MB FLASH EPROM. Image acquisition is by a 1/3" monochrome CCD camera with a 50mm lens, working through a beam splitter. A liquid crystal display (LCD) is used to feed back an image of the eye to the user. A 20 watt quartz-halogen luminaire powered at 7 watts provides illumination through a magenta filter. The proprietary, patented software and memory for up to 4,000 IrisCode files are stored in FLASH memory.

Enrollment requires serial port connection to a standard VGA or SVGA monitor and keyboard.

C.3 THE PROCESS

The system acquires images at 30 frames per second. Each digitized frame is analyzed for focus and clarity. When an acceptable image is selected, the system locates the pupil center, the pupil boundary and the limbus (the boundary between the iris and the sclera). This defines the iris.

Zones of analysis are next superimposed on the iris. These are eight concentric circles, which are then truncated (cut off) at the top between the 10 o'clock and 2 o'clock positions and on the bottom between the 4 o'clock and 8 o'clock positions. This is done to avoid eyelid occlusion and also reflections which frequently occur in the area of the 6 o'clock and 12 o'clock positions. The previously identified features of the iris are located within the zones of analysis, using a polar coordinate system. The proprietary software creates a 256 byte IrisCode, which is stored as the template file for the presented eye.

C.4 THE COMPARISON

When an applicant presents an iris to the system, an IrisCode is created, as described above. The system then compares the new IrisCode to all of the IrisCode files in the database. Hamming Distance (HD) is used as a quantitative measure of how different the presented IrisCode is from the stored template IrisCodes. An HD value is calculated by comparison of each of the 2,048 bits in the new IrisCode to its counterpart in a database IrisCode. If the two bits are alike (both "1" or both "0"), a value of zero is assigned to that comparison. If the two bits are different, a value of one is assigned to that pair comparison. After all pairs are compared, the assigned values are summed, and divided by the total number of pair comparisons, resulting in a two-digit fractional number which is a quantitative expression of how different the two IrisCodes are. (Sometimes the full 2,048 pairs are not compared because the system detects and excludes spectral reflections which were not present during enrollment.)

The system selects the stored template file with the smallest HD as the potential identification match. If that HD is less than the pre-selected HD criterion, the identification is made. If no comparison results in an HD which meets the criterion, the applicant is rejected as not being an enrolled person.

(The mathematical theory behind IriScan's patented process is further described in Appendix D, Dr. John Daugman's paper entitled, "High Confidence Visual Recognition of Persons by a Test of Statistical Independence.")

APPENDIX D

High Confidence Visual Recognition of Persons by a Test of Statistical Independence

John G. Daugman

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High Confidence Visual Recognition of Persons by a Test of Statistical Independence

John G. Daugman

Abstract—**A method for rapid visual recognition of personal identity is described, based on the failure of a statistical test of independence. The most unique phenotypic feature visible in a person's face is the detailed texture of each eye's iris: An estimate of its statistical complexity in a sample of the human population reveals variation corresponding to several hundred independent degrees-of-freedom. Morphogenetic randomness in the texture expressed phenotypically in the iris trabecular meshwork ensures that a test of statistical independence on two coded patterns originating from different eyes is passed almost certainly, whereas the same test is failed almost certainly when the compared codes originate from the same eye. The visible texture of a person's iris in a real-time video image is encoded into a compact sequence of multi-scale quadrature 2-D Gabor wavelet coefficients, whose most-significant bits comprise a 256-byte "iris code." Statistical decision theory generates identification decisions from Exclusive-OR comparisons of complete iris codes at the rate of 4 000 per second, including calculation of decision confidence levels. The distributions observed empirically in such comparisons imply a theoretical "cross-over" error rate of one in 131 000 when a decision criterion is adopted that would equalize the false accept and false reject error rates. In the typical recognition case, given the mean observed degree of iris code agreement, the decision confidence levels correspond formally to a conditional false accept probability of one in about 10^{31}.**

Index Terms—**Image analysis, statistical pattern recognition, biometric identification, statistical decision theory, 2-D Gabor filters, wavelets, texture analysis, morphogenesis.**

I. Introduction

EFFORTS to devise reliable mechanical means for biometric personal identification have a long and colorful history. In the Victorian era for example, inspired by the birth of criminology and a desire to identify prisoners and malefactors, Sir Francis Galton F.R.S. [13] proposed various biometric indices for facial profiles which he represented numerically. Seeking to improve on the system of French physician Alphonse Bertillon for classifying convicts into one of 81 categories, Galton devised a series of spring-loaded "mechanical selectors" for facial measurements and established an Anthropometric Laboratory at South Kensington [13]. Other biometric identifiers that have been adopted historically, ranging from cranial dimensions to digit length, as well as some of the numerous geometric facial measurements currently being tried, are described in [17], [25].

Today there is renewed interest in reliable, rapid, and unintrusive means for automatically recognizing the identity of persons. Security breaches in access to restricted areas at airports are known to have contributed to terrorism; and credit card fraud now costs six billion dollars annually [3]. Other applications for high confidence personal identification include passport control, bank automatic teller machines, protected access to premises or assets, law enforcement, government intelligence, entitlement verification, birth certificates, licenses, and any existing use of keys or cards. Some of the identifying biometric features now under investigation for potential use include hand geometry, blood vessel patterns in the retina or hand, fingerprints, voice-prints, and handwritten signature dynamics. The critical attributes for any such measure are: the number of degrees-of-freedom of variation in the chosen index across the human population, since this determines uniqueness; its immutability over time and its immunity to intervention; and the computational prospects for efficiently encoding and reliably recognizing the identifying pattern.

The possibility that the iris of the eye might be used as a kind of optical fingerprint for personal identification was suggested originally by ophthalmologists [1], [12], [24], who noted from clinical experience that every iris had a highly detailed and unique texture, which remained unchanged in clinical photographs spanning decades (contrary to the occult diagnostic claims of "iridology"). Among the visible features in an iris, some of which may be seen in the close-up image of Fig. 1, are the trabecular meshwork of connective tissue (pectinate ligament), collagenous stromal fibres, ciliary processes, contraction furrows, crypts, a serpentine vasculature, rings, corona, coloration, and freckles [1], [11], [12], [24]. The striated trabecular meshwork of chromatophore and fibroblast cells creates the predominant texture under visible light [24], but all of these sources of radial and angular variation taken together constitute a distinctive "fingerprint" that can be imaged at some distance from the person. Further properties of the iris that enhance its suitability for use in automatic identification include 1) its inherent isolation and protection from the external environment, being an internal organ of the eye, behind the cornea and the aqueous humor; 2) the impossibility of surgically modifying it without unacceptable risk to vision; and 3) its physiological response to light, which provides a natural test against artifice.

A property the iris shares with fingerprints is the random morphogenesis of its minutiae. Because there is no genetic

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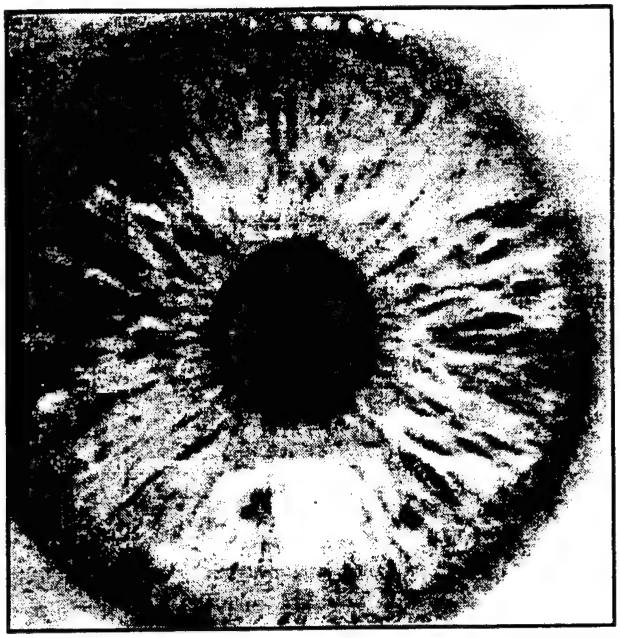

Fig. 1. Close-up image illustrating the trabecular meshwork and other features of a human iris.

penetrance in the expression of this organ beyond its anatomical form, physiology, color and general appearance, the iris texture itself is stochastic or possibly chaotic. Since its detailed morphogenesis depends on initial conditions in the embryonic mesoderm from which it develops [11], the phenotypic expression even of two irises with the same genetic genotype (as in identical twins, or the pair possessed by one individual) have uncorrelated minutiae. In these respects the uniqueness of every iris parallels the uniqueness of every fingerprint, common genotype or not. But the iris enjoys further practical advantages over fingerprints and other biometrics for purposes of automatic recognition, including 4) the ease of registering its image at some distance from the Subject without physical contact, unintrusively and perhaps inconspicuously; and 5) its intrinsic polar geometry, which imparts a natural coordinate system and an origin of coordinates.

Unknown until the present work was whether mathematically there were sufficient degrees-of-freedom, or forms of variation in the iris among individuals, to impart to it the same singularity as a conventional fingerprint. Also uncertain was whether efficient algorithms could be developed to extract a detailed iris description reliably from a live video image, generate a compact code for the iris (of minuscule length compared with image data size), and render a decision about individual identity with high statistical confidence, all within less than one second of computation time on a general-purpose microprocessor. The present report resolves all of these questions affirmatively and describes a working system.

II. Image Analysis

A. Operators for Locating an Iris

Iris analysis begins with reliable means for establishing whether an iris is visible in the video image, and then precisely locating its inner and outer boundaries (pupil and limbus). Because of the felicitous circular geometry of the iris, these tasks can be accomplished for a raw input image $I(x, y)$ by integrodifferential operators that search over the image domain (x, y) for the maximum in the blurred partial derivative, with respect to increasing radius r, of the normalized contour integral of $I(x, y)$ along a circular arc ds of radius r and center coordinates (x_0, y_0):

$$\max_{(r,x_0,y_0)}\left|G_\sigma(r) * \frac{\partial}{\partial r}\oint_{r,x_0,y_0}\frac{I(x,y)}{2\pi r}ds\right|, \tag{1}$$

where $*$ denotes convolution and $G_\sigma(r)$ is a smoothing function such as a Gaussian of scale σ. The complete operator behaves in effect as a circular edge detector, blurred at a scale set by σ, that searches iteratively for a maximum contour integral derivative with increasing radius at successively finer scales of analysis through the three parameter space of center coordinates and radius (x_0, y_0, r) defining the path of contour integration.

At first the blurring factor σ is set for a coarse scale of analysis so that only the very pronounced circular transition from iris to (white) sclera is detected. Then after this strong circular boundary is more precisely estimated, a second search begins within the confined central interior of the located iris for the fainter pupillary boundary, using a finer convolution scale σ and a smaller search range defining the paths (x_0, y_0, r) of contour integration. In the initial search for the outer bounds of the iris, the angular arc of contour integration ds is restricted in range to two opposing 90° cones centered on the horizontal meridian, since eyelids generally obscure the upper and lower limbus of the iris. Then in the subsequent interior search for the pupillary boundary, the arc of contour integration ds in operator (1) is restricted to the upper 270° in order to avoid the corneal specular reflection that is usually superimposed in the lower 90° cone of the iris from the illuminator located below the video camera. Taking the absolute value in (1) is not required when the operator is used first to locate the outer boundary of the iris, since the sclera is always lighter than the iris and so the smoothed partial derivative with increasing radius near the limbus is always positive. However, the pupil is not always darker than the iris, as in persons with normal early cataract or significant back-scattered light from the lens and vitreous humor; applying the absolute value in (1) makes the operator a good circular edge-finder regardless of such polarity-reversing conditions. With σ automatically tailored to the stage of search for both the pupil and limbus, and by making it correspondingly finer in successive iterations, the operator defined in (1) has proven to be virtually infallible in locating the visible inner and outer annular boundaries of irises.

For rapid discrete implementation of the integrodifferential operator in (1), it is more efficient to interchange the order of convolution and differentiation and to concatenate them, before computing the discrete convolution of the resulting operator with the discrete series of undersampled sums of pixels along circular contours of increasing radius. Using the finite difference approximation to the derivative for a discrete

series in n,

$$\frac{\partial G_\sigma(r)}{\partial r} \approx G_\sigma^{(1)}(n) = \frac{1}{\Delta r} G_\sigma(n\Delta r) - \frac{1}{\Delta r} G_\sigma((n-1)\Delta r), \quad (2)$$

where Δr is a small increment in radius, and replacing the convolution and contour integrals with sums, we can derive through these manipulations an efficient discrete operator (see (3) at the bottom of the page) for finding the inner and outer boundaries of an iris where $\Delta\theta$ is the angular sampling interval along the circular arcs, over which the summed $I(x, y)$ pixel intensities represent the contour integrals expressed in (1).

A nonlinear enhancement of this operator makes it more robust for detecting the inner boundary of the iris. Because the circular edge that defines the pupillary boundary is often very faint, especially in dark-eyed persons, it is advantageous to divide each term in the convolution summation over k in (3) by a further contour integral around a smaller radius $(k-2)\Delta r$. This divisor becomes very small and stable as the parameters $(n\Delta r, x_0, y_0)$ of contour integration become well-matched to the true location and size of the pupil, and this helps the resulting sum of ratio terms (see (4) at the bottom of the page) to achieve a distinctive maximum that reliably locates the pupillary boundary. In essence, dividing by the second contour integral exploits the fact that the interior of the pupil is generally both homogeneous and dark. This creates a suddenly very small divisor when the parameters $(n\Delta r, x_0, y_0)$ are optimal for the true pupil, thus producing a sharp maximum in the overall search operator (4).

Using multigrid search with gradient ascent over the image domain (x, y) for the center coordinates and initial radius of each series of contour integrals, and decimating both the incremental radius interval Δr and the angular sampling interval $\Delta\theta$ in successively finer scales of search spanning four octaves, these iris locating operations become very efficient without loss of reliability. The total processing time on a RISC-based CPU for iris detection and localization to single-pixel precision using such operators, starting from a 640 x 480 image, is about one-quarter of a second (250 msec) with optimized integer code.

B. Assessing Image Quality, Eyelid Occlusion, and Possibility of Artifice

The operators previously described for finding an iris also provide a good assessment of "eyeness," and of the autofocus performance of the video camera. The normally sharp boundary at the limbus between the iris and the (white) sclera generates a large positive circular edge; if a derivative larger than a certain criterion is not detected by the searching operator using the contour integral defined in (3), then this suggests either that no eye is present, or that it is largely obscured by eyelids, or that it is in poor focus or beyond resolution. In practice the automatic identifying system that has been built continues to grab image frames in rapid succession until several frames in sequence confirm that an eye is present and in focus, through large values being found by operator (3), and through large ratios of circular contour integrals being found on either side of the putative limbus boundary. Excessive eyelid occlusion is alleviated in cooperating Subjects by providing live video feedback through the lens of the video camera into which the Subject's gaze is directed, by means of a miniature liquid-crystal TV monitor displaying the magnified image through a beamsplitter in the optical axis.

A further test for evidence that a living eye is present exploits the fact that pupillary diameter relative to iris diameter in a normal eye is constantly changing, even under steady illumination [1], [11]. Continuous involuntary oscillations in pupil size, termed hippus or pupillary unrest, arise from normal fluctuations in the activities of both the sympathetic and parasympathetic innervation of the iris sphincter muscle [1]. These changes in pupil diameter relative to iris diameter over a sequence of frames are detected by the discrete operators (4) and (3), respectively, in order to compute a "hippus measure" defined as the coefficient of variation (standard deviation divided by mean) for the fluctuating time series of these diameter ratios. Together with the accompanying elastic deformations in the iris texture itself arising either from normal hippus or from a light-driven pupillomotor response, these fluctuations could provide a test against artifice (such as a fake iris painted onto a contact lens) if necessary in highly secure implementations of this system.

$$\max_{(n\Delta r, x_0, y_0)} \left| \frac{1}{\Delta r} \sum_k \left\{ \left(G_\sigma((n-k)\Delta r) - G_\sigma((n-k-1)\Delta r) \right) \sum_m I\left[(k\Delta r \cos(m\Delta\theta) + x_0), (k\Delta r \sin(m\Delta\theta) + y_0) \right] \right\} \right|, \quad (3)$$

$$\max_{(n\Delta r, x_0, y_0)} \left| \sum_k \left\{ \frac{\left(G_\sigma((n-k)\Delta r) - G_\sigma((n-k-1)\Delta r) \right) \sum_m I\left[(k\Delta r \cos(m\Delta\theta) + x_0), (k\Delta r \sin(m\Delta\theta) + y_0) \right]}{\Delta r \sum_m I\left[((k-2)\Delta r \cos(m\Delta\theta) + x_0), ((k-2)\Delta r \sin(m\Delta\theta) + y_0) \right]} \right\} \right|. \quad (4)$$

C. Two-Dimensional Gabor Filters

An effective strategy for extracting both coherent and incoherent textural information from images, such as the detailed texture of an iris, is the computation of 2-D Gabor phasor coefficients. This family of 2-D filters were originally proposed in 1980 by Daugman [8] as a framework for understanding the orientation-selective and spatial-frequency-selective receptive field properties of neurons in the brain's visual cortex, and as useful operators for practical image analysis problems. Their mathematical properties were further elaborated by the author in 1985 [9], who pointed out that such 2-D quadrature phasor filters were conjointly optimal in providing the maximum possible resolution both for information about the orientation and spatial frequency content of local image structure ("what"), simultaneously with information about 2-D position ("where"). The complex-valued family of 2-D Gabor filters uniquely achieves the theoretical lower bound for conjoint uncertainty over these four variables, as dictated by an inescapable uncertainty principle [9].

These properties are particularly useful for texture analysis [2], [4]–[7], [10], [14]–[16], [18], [23], [29]–[31] because of the 2-D spectral specificity of texture as well as its variation with 2-D spatial position. A rapid method for obtaining the required coefficients on these elementary functions for the purpose of representing any image completely by its 2-D Gabor Transform, despite the non-orthogonality of the expansion basis, was given in [10] through the use of a relaxation network. A large and growing literature now exists on the efficient use of this nonorthogonal expansion basis and its applications (e.g., [2], [14], [23], [28]).

Two-dimensional Gabor filters over the image domain (x, y) have the functional form

$$G(x,y) = e^{-\pi[(x-x_0)^2/\alpha^2+(y-y_0)^2/\beta^2]} \cdot e^{-2\pi i[u_0(x-x_0)+v_0(y-y_0)]} \qquad (5)$$

where (x_0, y_0) specify position in the image, (α, β) specify effective width and length, and (u_0, v_0) specify modulation, which has spatial frequency $\omega_0 = \sqrt{u_0^2 + v_0^2}$ and direction $\theta_0 = \arctan(v_0/u_0)$. (A further degree-of-freedom included below but not captured above in (5) is the relative orientation of the elliptic Gaussian envelope, which creates cross-terms in xy.) The 2-D Fourier transform $F(u, v)$ of a 2-D Gabor filter has exactly the same functional form, with parameters just interchanged or inverted [9]:

$$F(u,v) = e^{-\pi[(u-u_0)^2\alpha^2+(v-v_0)^2\beta^2]} e^{-2\pi i[x_0(u-u_0)+y_0(v-v_0)]}. \qquad (6)$$

The real part of one member of the 2-D Gabor filter family, centered at the origin $(x_0, y_0) = (0, 0)$ and with aspect ratio $\beta/\alpha = 1$ is shown in Fig. 2, together with its 2-D Fourier transform $F(u, v)$.

2-D Gabor functions can form a complete self-similar wavelet expansion basis [10], with the requirements of orthogonality and strictly compact support [20]–[21] relaxed, by appropriate parameterization for dilation, rotation, and translation. If we take $\Psi(x, y)$ to be a chosen generic 2-D Gabor wavelet, then we can generate from this member

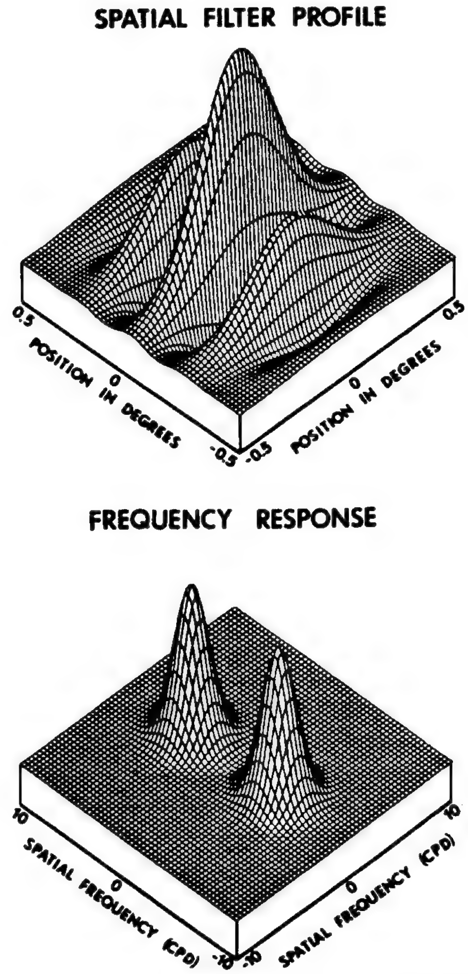

Fig. 2. The real part of a 2-D Gabor wavelet, and its 2-D Fourier transform (from Daugman (1980) [8]).

a complete self-similar family of 2-D wavelets through the generating function

$$\Psi_{mpq\theta}(x,y) = 2^{-2m}\Psi(x',y'), \qquad (7)$$

where the substituted variables (x', y') incorporate dilations of the wavelet in size by 2^{-m}, translations in position (p, q), and rotations through angle θ:

$$x' = 2^{-m}[x\cos(\theta) + y\sin(\theta)] - p \qquad (8)$$

$$y' = 2^{-m}[-x\sin(\theta) + y\cos(\theta)] - q. \qquad (9)$$

It is noteworthy [9] that as consequences of the similarity theorem, shift theorem, and modulation theorem of Fourier analysis, together with the rotation isomorphism of the Fourier transform, all of these effects of the generating function (7) applied to a 2-D Gabor mother wavelet $\Psi(x, y) = G(x, y)$ in order to generate a 2-D Gabor daughter wavelet $\Psi_{mpq\theta}(x, y)$ have corresponding or reciprocal effects on its Fourier transform $F(u, v)$ without any change in functional form. This family of wavelet filters and their Fourier transforms is closed

under the transformation group of dilations, translations, rotations, and convolutions [9]. We will exploit these self-similarity properties of 2-D Gabor filters in analyzing iris textures across multiple scales to construct identifying codes.

D. Doubly Dimensionless Projected Polar Coordinate System

Zones of analysis are established on the iris in a doubly dimensionless projected polar coordinate system. Its purpose is to maintain reference to the same regions of iris tissue regardless both of pupillary constriction and overall iris image size, and hence regardless of distance to the eye and video zoom factor. This pseudo polar coordinate system is not necessarily concentric, since for most eyes the pupil is not central in the iris. (Typically the pupil is both nasal to, and inferior to, the center of the iris [1], and it is not unusual for its displacement to be as great as 15%.) The stretching of the elastic trabecular meshwork of the iris from constriction of the pupil is intrinsically modelled by the doubly dimensionless projected coordinate system as the stretching of a homogeneous rubber sheet, having the topology of an annulus anchored along its outer perimeter, with tension controlled by an off-centered interior ring of variable radius.

The homogeneous rubber sheet model assigns to each point in the iris, regardless of size and pupillary dilation, a pair of dimensionless real coordinates (r, θ) where r lies on the unit interval $[0,1]$ and θ is the usual angular quantity that is cyclic over $[0, 2\pi]$. The remapping of the iris image $I(x, y)$ from raw coordinates (x, y) to the doubly dimensionless nonconcentric polar coordinate system (r, θ) can be represented as

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \qquad (10)$$

where $x(r,\theta)$ and $y(r,\theta)$ are defined as linear combinations of both the set of pupillary boundary points $(x_p(\theta), y_p(\theta))$ around the circle that was found to maximize operator (4), and the set of limbus boundary points along the outer perimeter of the iris $(x_s(\theta), y_s(\theta))$ bordering the sclera, that was found to maximize operator (3):

$$x(r,\theta) = (1-r)x_p(\theta) + rx_s(\theta) \qquad (11)$$

$$y(r,\theta) = (1-r)y_p(\theta) + ry_s(\theta). \qquad (12)$$

Demarcations of the zones of analysis specified in this projected doubly dimensionless coordinate system, for two sample close-up iris images, are illustrated in Figs. 3 and 4. These zones of analysis are assigned in the same format for all eyes and are based on a fixed partitioning of the dimensionless polar coordinate system, but of course for any given eye their affine radial scaling depends on the actual pupillary diameter (and possible offset) relative to the limbus boundary as determined by operators (3) and (4). The zones of analysis always exclude a region at the top of the iris where partial occlusion by the upper eyelid is common, and a 45° notch at the bottom where there is a corneal specular reflection from the filtered light source that illuminates the eye from below.

Fig. 3. Demarcated zones of analysis and illustration of a computed iris code.

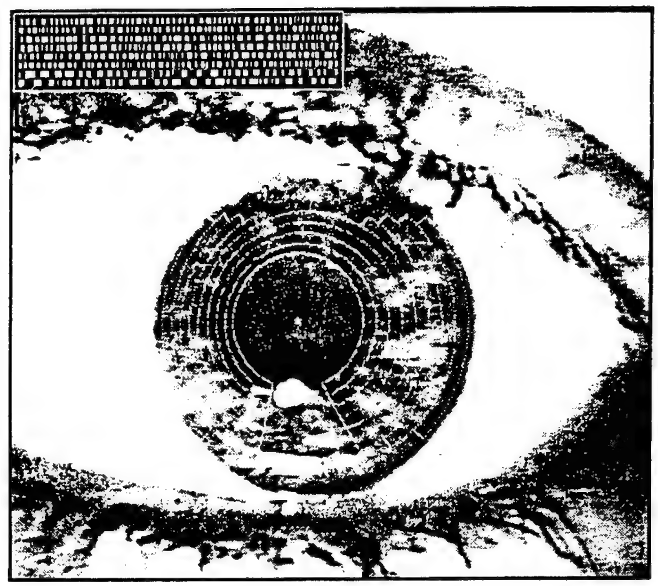

Fig. 4. Demarcated zones of analysis and illustration of a computed iris code.

(Illumination at an angle is desirable to deflect its specular reflection from eye-glasses, which persons are not asked to remove. The much greater curvature of the cornea compared with that of spectacle lenses, however, prevents elimination of the illuminator's first Purkinje reflection from the moist lower front surface of the cornea or of contact lenses; this necessitates the exclusion notch in the zones of analysis near the 6-o'clock position.)

Rotation invariance to correct for head tilt and cyclovergence of the eye within its orbit is achieved in a subsequent stage of analysis of the iris code itself. The overall recognition scheme is thus invariant under the Poincaré group of transformations of the iris image: planar translation, rotation (due to cyclovergence and tilt of the head), and dilation (due both to imaging distance and video zoom factor). Through the doubly dimensionless coordinate system, the constructed iris code is also invariant under the nonaffine elastic distortion (or projected conic transformation) that arises from variable pupil constriction.

III. Code Construction and Entropy Measures

An uncompressed code length of 256 bytes was chosen because this is roughly the capacity of the three-channel magnetic stripe affixed to the reverse side of the standard IS-7811 credit/debit card [3]. But this absolute code length only establishes an upper bound on the information capacity of an iris code, and it is important to know its actual inherent capacity. This capacity is reduced by intrinsic correlations, if any, among the coding primitives themselves. It is then also important to know the "source entropy" associated with the typical human iris signal, which will be much less than the upper bound determined by the resolution of imaging, because of inherent correlations (especially radial) within the iris. These reduced entropies directly influence the confidence levels associated with any decision strategy. In the methods to be described here, irises are efficiently recognized by executing a statistical test of independence on their codes. In effect, this examines whether the degree to which one iris code predicts another iris code, is compatible with the hypothesis that they arise from independent random processes. Such a test of statistical independence is passed almost certainly for two iris codes from different eyes, but the same test is failed almost certainly when the compared signatures originate from the same eye.

A. The 256-Byte Iris Code

The 2-D Gabor filters used for iris recognition are defined in the doubly dimensionless polar coordinate system (r, θ) as follows:

$$G(r,\theta) = e^{-i\omega(\theta-\theta_0)}e^{-(r-r_0)^2/\alpha^2}e^{-(\theta-\theta_0)^2/\beta^2}. \tag{13}$$

Both the real and imaginary members of such quadrature filters are employed, so the resulting image projections are complex. The real parts of the 2-D Gabor filters are slightly adjusted through truncation to give them zero volume, and hence no dc response, so that computed iris code bits do not depend upon strength of illumination. (The imaginary parts of the filters inherently have no dc response because of odd symmetry.) The parameters α and β co-vary in inverse proportion to ω to generate a self-similar, multi-scale wavelet family of 2-D frequency-selective quadrature filters with constant logarithmic bandwidth, whose locations, specified by θ_0 and r_0, range across the zones of analysis of the iris.

Each bit h in an iris code can be regarded as a coordinate of one of the four vertices of a logical unit square in the complex plane. It is computed by evaluating, at one scale of analysis, the sign of both the real and imaginary parts of the quadrature image projections from a local region of the iris image $I(\rho, \phi)$ onto a particular complex 2-D Gabor filter:

$$h_{\mathrm{Re}} = 1 \text{ if } \mathrm{Re} \int_\rho \int_\phi e^{-i\omega(\theta_0-\phi)}e^{-(r_0-\rho)^2/\alpha^2} \cdot e^{-(\theta_0-\phi)^2/\beta^2} I(\rho,\phi)\rho d\rho d\phi \geq 0, \tag{14}$$

$$h_{\mathrm{Re}} = 0 \text{ if } \mathrm{Re} \int_\rho \int_\phi e^{-i\omega(\theta_0-\phi)}e^{-(r_0-\rho)^2/\alpha^2} \cdot e^{-(\theta_0-\phi)^2/\beta^2} I(\rho,\phi)\rho d\rho d\phi < 0, \tag{15}$$

$$h_{\mathrm{Im}} = 1 \text{ if } \mathrm{Im} \int_\rho \int_\phi e^{-i\omega(\theta_0-\phi)}e^{-(r_0-\rho)^2/\alpha^2} \cdot e^{-(\theta_0-\phi)^2/\beta^2} I(\rho,\phi)\rho d\rho d\phi \geq 0, \tag{16}$$

$$h_{\mathrm{Im}} = 0 \text{ if } \mathrm{Im} \int_\rho \int_\phi e^{-i\omega(\theta_0-\phi)}e^{-(r_0-\rho)^2/\alpha^2} \cdot e^{-(\theta_0-\phi)^2/\beta^2} I(\rho,\phi)\rho d\rho d\phi < 0. \tag{17}$$

Thus, a single complex 2-D Gabor filter (13), having a particular set of size and position parameters $(r_0, \theta_0; \alpha, \beta, \omega)$ in the dimensionless iris domain (r, θ), performs a coarse phase quantization of the local texture signal by approximating it as one vertex $(h_{\mathrm{Re}}, h_{\mathrm{Im}})$ of the logical unit square associated with this filter through conditionals (14)–(17). The time required for computing a complete iris code of 2 048 such paired bits (256 bytes) on a RISC-based CPU, once an iris has been located within the image, is about one-tenth of a second (100 msec) with optimized integer code.

B. Commensurability of Iris Codes

A critical feature of this coding approach is the achievement of commensurability among iris codes, by mapping all irises into a representation having universal format and constant length, regardless of the apparent amount of iris detail. In the absence of commensurability among the codes, one would be faced with the inevitable problem of comparing long codes with short codes, showing partial agreement and partial disagreement in their lists of features. It is not obvious mathematically how one would make objective decisions and compute confidence levels on a rigorous basis in such a situation. This difficulty has hampered efforts to automate reliably the recognition of fingerprints. Commensurability facilitates and objectifies the code comparison process, as well as the computation of confidence levels for each decision. It thereby greatly increases both the speed and the reliability of iris recognition decisions.

C. Bitwise Entropy and Iris Variation

A primary question is whether there is independent variation in iris detail, both within a given iris and across the human population. Any systematic correlations in iris detail across the population would undermine the uniqueness of an iris code. Similarly, any systematic correlations within an iris would reduce its statistical complexity, or dimensionality, and thus also undermine its uniqueness.

A code of any length has maximum information capacity if all its possible states are equiprobable [26]. This reflects the fact that the Shannon entropy measure

$$S = -\sum_{j=1}^{n} P_j \log_2 P_j, \tag{18}$$

for P_j the probability of each of the n states and with

$$\sum_{j=1}^{n} P_j = 1 \tag{19}$$

is maximum when for all j,

$$P_j = 1/n. \tag{20}$$

By construction, the 2-D Gabor filters (13) have no DC response in either their real or imaginary parts, as noted earlier. This eliminates possible dependency of the computed code bit conditionals (14)–(17) on mean illumination of the iris and on its contrast gain, and it also renders equiprobable the four vertices of the logical unit square $(h_{\mathrm{Re}}, h_{\mathrm{Im}})$ associated with each 2-D Gabor filter. As a consequence of analyzing the iris texture with filters lacking any dc response, the iris code has the property of encoding zero-crossings, which are known [19] to be exceedingly rich in information for band-limited signals.

The variation among iris code bits as defined above in (14)–(17) was tracked both across bit location within the code and across a population of 592 different iris codes. The ethnic groups and nationalities included in this sample are listed in Section V-A, together with further database details. For each of 128 code bit locations, drawn from all parts of the iris code, Fig. 5 plots the probability of a set bit. The graph shows that this is fairly equiprobable across all code bit locations, and that it remains close to one-half. (Mean of the means is 0.4984 ± 0.0244). The flatness of the graph reflects the existence of independent variation in the detailed iris texture, both across an iris and across the human population studied. The amount of independent variation that is typical in a given iris will be quantified in the following section, which estimates the underlying number of independent degrees-of-freedom in an iris code after its intrinsic correlations have been factored out. Across the population, the constant independent probability of any given code bit being set (i.e., the full equivocation entropy between iris codes) presumably reflects the absence of genetic penetrance in the detailed morphogenesis of this tissue, in favor of stochastic or chaotic processes. Any systematic feature, say at the 12-o'clock position in the iris, would have caused systematic deviation in Fig. 5 for the bit probabilities derived from that region. Second, this graph's proximity to a probability of one-half establishes that, since very nearly $p = 1 - p$, the iris code is bitwise a maximum entropy code.

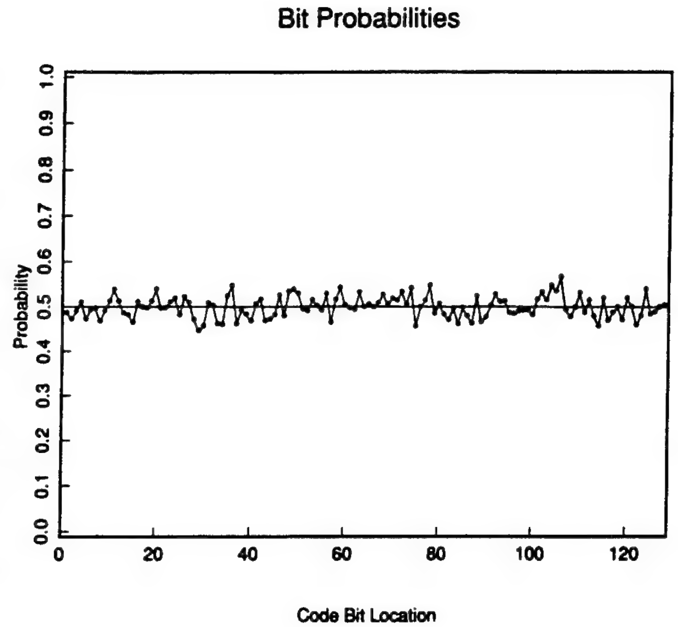

Fig. 5. Equiprobable variation of iris code bits, for each of 128-code bit locations, across a population of 592 different iris codes.

D. Number of Independent Degrees-of-Freedom in an Iris Code

Although there are 256 bytes or 2 048 bits in any given iris code, such a code possesses far fewer than 2 048 independent binary degrees-of-freedom. One reason is that there are substantial radial correlations within an iris. For example, a given furrow or ciliary process tends to propagate across a significant radial distance in the iris, exerting its influence on several remote parts of the code, thus reducing their independence. Similarly, a feature such as a furrow influences different parts of the code associated with several different scales of analysis, since the Fourier spectrum of such a punctate feature can span several octaves. Finally, inherent correlations are introduced by the bandpass property of the 2-D Gabor filters, specifically by the finite bandwidth determined by parameters α, β, and ω in (13).

As pointed out by Wiener [32], any signal convolved with a linear filter acquires a correlation distance that is greater than or equal to the reciprocal of the bandwidth of the filter. This property is well-known for low-pass filters but is perhaps less widely recognized for bandpass filters. Even though the peak response of the bandpass filter might be at a very high frequency, its passband introduces phase coherence that lingers for a greater number of cycles, the narrower its bandwidth. (This is easily grasped by considering the limiting case of the coherent response generated by a notch-pass filter.) In the present case, the correlations introduced inherently by the band-limited 2-D Gabor filters alone reduce the information capacity of the iris code by a factor of 4.05, from 2 048 bits to about 506 bits, given the values of α, β, ω and the sampling densities employed at the different scales of analysis.

The number of independent degrees-of-freedom typically remaining in an iris code after both of these sources of correlation have been factored in (those arising from the 2-D Gabor filters and those inherent within an iris), can be estimated by examining the distribution of Hamming distances computed across a population of unrelated iris codes. Comparing each pair of iris codes A and B bit-by-bit, their normalized Hamming distance HD is defined here as the fraction of disagreeing bits between them:

$$\mathrm{HD} = \frac{1}{2,048} \sum_{j=1}^{2,048} A_j(\mathrm{XOR})B_j \tag{21}$$

where the Boolean operator (XOR) equals 1, if and only if the two bits A_j and B_j are different.

Since each bit of any iris code has equal *a priori* odds of being a 1 or a 0, there is probability $p = 0.5$ that any pair

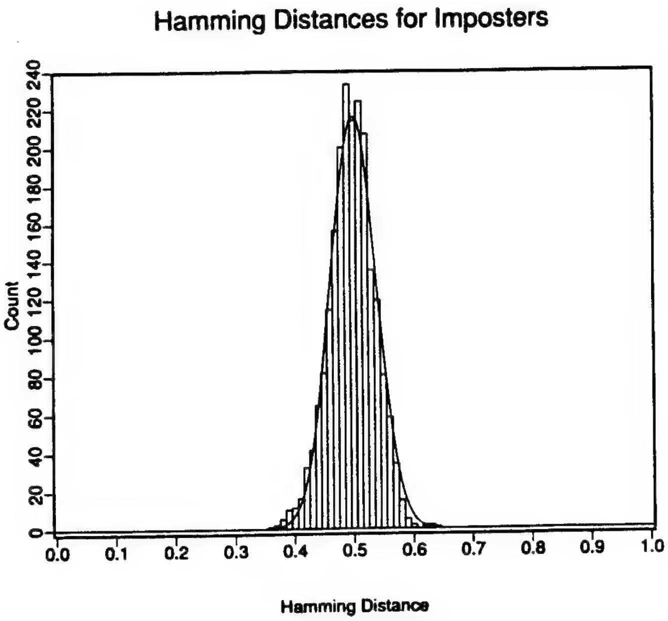

Fig. 6. Distribution of Hamming distances between unrelated iris codes. Solid curve is (22).

of bits from different iris codes disagree. (Each of the four states 00, 01, 10, 11 has probability 0.25; the bits agree in two cases and disagree in the other two.) If each of the 2,048 bits in a given iris code were fully independent of every other bit, then the expected distribution of observed Hamming distances between two independent such iris codes would be a binomial distribution with $p = 0.5$ and $N = 2\,048$ (in other words, equivalent to tossing a fair coin 2 048 times, and counting the fraction of heads in each round of 2 048 tosses). Once the intrinsic code correlations introduced by the 2-D Gabor filters were factored in, the distribution should be a binomial with $p = 0.5$ and $N = 506$ if the iris itself had no inherent correlations.

The actual distribution of observed Hamming distances between codes for different irises is shown in Fig. 6, which is generated from 2 064 complete comparisons between unrelated pairs of iris codes. This empirical distribution has a standard deviation of $\sigma = 0.038$, with a mean of $\mu = 0.497$. Since the standard deviation of a binomial distribution is given by $\sigma = \sqrt{pq/N}$ (where $q = 1 - p$), this distribution of Hamming distances would correspond to a binomial process with $N = 173$ Bernoulli trials per run. Given the estimate of roughly a four-sample correlation distance introduced by the 2-D Gabor encoders, we can now estimate that a bound on the "source entropy," reflecting the number of degrees-of-freedom of variation typical of iris texture resolved to 2 048 samples, would be something like 690 bits.

The binomial distribution for N Bernoulli trials with outcome probabilities p and q predicts that the likelihood of observing a fraction $x = m/N$ events among the N trials is:

$$f(x) = \frac{N!}{m!(N-m)!} p^m q^{(N-m)}. \tag{22}$$

A theoretical plot of the probability density function associated with such a binomial process having $N = 173$ and $p = 0.5$ is also shown in Fig. 6 as a smooth curve, and it offers a good fit to the data. In summary it appears that there exist the equivalent of about 173 independent binary degrees-of-freedom typically remaining in a 2 048-bit iris code, once both the correlations introduced by the 2-D Gabor filters and those inherent in the iris have been factored in. The likelihood of two iris codes from different irises agreeing completely by chance is thus roughly one in 2^{173}, or approximately 10^{-52}.

IV. Statistical Decision Theory

The problem of recognizing the signature of a given iris as belonging to a particular individual, either after exhaustive search through a large database or just by comparison with a single authentication template, can be formulated within the framework of statistical decision theory [22], [27]. This framework also resolves the critical problem of assigning a confidence level to any such recognition decision. By this approach we can convert the problem of pattern recognition into a much more expedient task, which is the execution of a simple test of statistical independence.

A. Neyman–Pearson Formalism

Yes/No recognition decisions have four possible outcomes: either a given pattern is, or is not, a true instance of the category in question; and in either case, the decision made by the algorithm may be either the correct one or the incorrect one. In the present application the four possible outcomes are termed Acceptance of Authentic (AA), Acceptance of Imposter (IA), Rejection of Authentic (AR), and Rejection of Imposter (IR). Obviously the first and fourth outcomes are desired, and the second and third outcomes are errors. The goal of the decision-making algorithm is to maximize the conditional probabilities of AA and IR, while minimizing the likelihoods of IA and AR. The pairwise trade-offs among the probabilities of these four outcomes can be manipulated in a way that reflects their associated costs and benefits in a particular application.

The Neyman–Pearson formalism for decision problems in which the prior probabilities are not known and the error costs are not fixed, but the posterior distributions are known, is summarized in Fig. 7. A given measurement of the Hamming distance between two iris codes constitutes a point on the abscissa. This measurement is regarded as being a sample from one of two random processes ("Authentics" or "Imposters"), whose probability distributions have been arbitrarily shown here as Gaussians with large overlap for purposes of illustration. The two distributions, $P_{\mathrm{Au}}(x)$ and $P_{\mathrm{Im}}(x)$, specify respectively the probability density of a particular measured Hamming distance, x, arising from two comparisons of the same iris, or from two comparisons of different irises. Any measured Hamming distance smaller than a chosen decision criterion, as indicated by the dotted line in Fig. 7, is judged to belong to the Authentics distribution, while any Hamming distance greater than this criterion is judged to belong to the Imposters distribution. The probabilities of the four possible

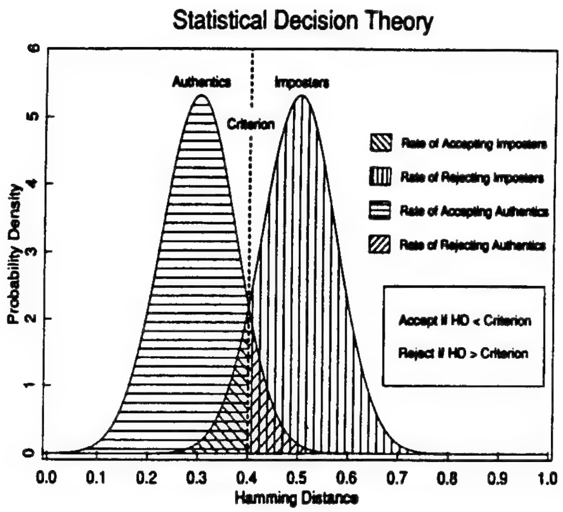

Fig. 7. Statistical decision theory: Formalism for decisions under uncertainty.

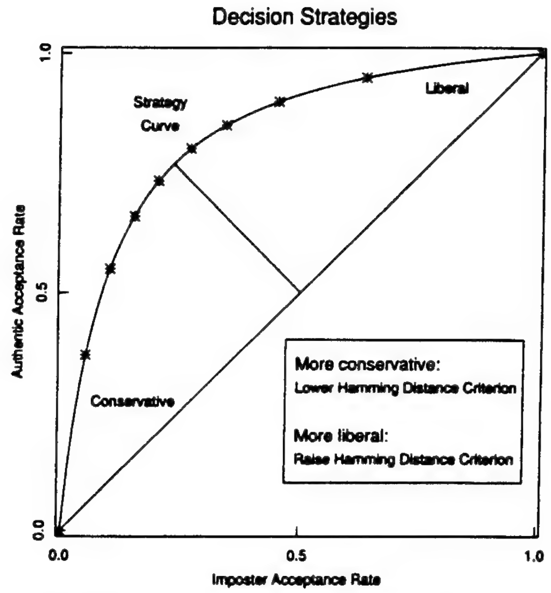

Fig. 8. The Neyman–Pearson decision strategy curve.

outcomes AA, IA, AR, and IR are equal to the areas under the two probability density functions, $P_{\mathrm{Au}}(x)$ and $P_{\mathrm{Im}}(x)$, on either side of the chosen decision criterion C:

$$P(AA) = \int_0^C P_{\mathrm{Au}}(x)dx, \tag{23}$$

$$P(AR) = \int_C^1 P_{\mathrm{Au}}(x)dx, \tag{24}$$

$$P(IA) = \int_0^C P_{\mathrm{Im}}(x)dx, \tag{25}$$

$$P(IR) = \int_C^1 P_{\mathrm{Im}}(x)dx. \tag{26}$$

These four probabilities are represented by the four shaded areas in Fig. 7.

B. Strategies and Decidability

It is clear that the four probabilities separate into two pairs that must sum to unity, and two pairs are governed by inequalities:

$$P(\mathrm{AA}) + P(\mathrm{AR}) = 1, \tag{27}$$

$$P(\mathrm{IA}) + P(\mathrm{IR}) = 1, \tag{28}$$

$$P(\mathrm{AA}) > P(\mathrm{IA}), \tag{29}$$

$$P(\mathrm{IR}) > P(\mathrm{AR}). \tag{30}$$

It is also clear that the error rates, $P(\mathrm{AR})$ and $P(\mathrm{IA})$, could be minimized if the two Hamming distance distributions, $P_{\mathrm{Au}}(x)$ and $P_{\mathrm{Im}}(x)$, had minimal overlap. Their overlap would be reduced if their two means were farther apart, or if their variances were smaller, of both. Of course, the two distributions in general will not be matched in form and variance, as was implied in Figure 7 for simplicity.

Manipulation of the decision criterion C in (23)–(26), in order to implement different decision strategies appropriate for the costs of either type of error in a given application, is illustrated schematically in Fig. 8. Such a decision strategy diagram, sometimes called a receiver operating characteristic or Neyman–Pearson curve, plots $P(\mathrm{AA})$ from (23) against $P(\mathrm{IA})$ from (25) as a locus of points. Each point in such a plot represents a decision strategy as specified by a different choice for the criterion C, as was indicated schematically in Fig. 7.

Inequality (29) states that the Neyman–Pearson strategy curve shown in Fig. 8 will always lie above the diagonal line. Clearly, strategies that were excessively conservative or excessively liberal would correspond to sliding along the curve towards the two diagonal extremes. Independent of where the decision criterion is placed along this continuum, the overall power of a pattern recognition method may be gauged by the length of the line segment in Fig. 8 joining the diagonal line and the bend in the strategy curve. This distance is monotonically related to the quantity d', for "detectability" or "decidability," defined as the difference between the means of the two distributions that were shown schematically in Fig. 7 divided by a conjoint measure of their standard deviations. This standard measure of statistical decidability has a value of about $d' = 8.4$ in the present work.

V. Performance

With this biometric recognition problem now formulated within the frameworks of signal processing and statistical decision theory, we can evaluate the identifiability of persons by their irises.

A. Database

The performance results reported here are based partly on a photographic database of eye images generously made available in 1989 by Ophthalmology Associates of Connecticut, which were digitized and then combined with further databases of images subsequently acquired directly with video cameras in Massachusetts and in Cambridgeshire, England. The total number of different eyes represented in the combined database was 592, in images acquired over a three year period from 323 persons. Multiple images were always acquired from each person, ranging from 2 to 10 images of each eye over the time period (average 3.04 images per eye). Some images were rejected manually because of excessive eyelid closure or poor focus, before the automatic operators to perform these tasks as described in Section 2.2 were developed. Images in RS-170, VHS (NTSC), and S-VHS (NTSC) formats were digitized by 480 x 640 monochrome 8-bit/pixel framegrabber boards in either Macintosh or (by SCSI interface) SUN sparcstation hosts. Image resolution and iris size within the images varied due to both distance and video zoom factor, but the outer diameter of the iris was always greater than 60 pixels and was usually in the range of 100 pixels to 200 pixels. Imaging distances ranged from 46 cm to 15 cm, normally through a 330-mm positive meniscus lens. Ethnic groups and nationalities represented in the combined databases included persons of Northern European, Mediterranean, Eastern European, Indian, Semitic, Afro-American, Hispanic-American, Japanese, and Chinese origin.

B. Imposters' Hamming Distances

The distribution of Hamming distances generated by 2064 direct comparisons between pairwise unrelated iris codes was seen previously in Fig. 6. The average Hamming distance was very close to 0.5 since any pair of corresponding bits in the codes for two different irises have equal probability of agreeing or disagreeing. The raw distribution was well described by a suitably fitted binomial model, whose effective number of implicit Bernoulli trials was appropriately reduced to factor out the residual correlations that exist among the bits within a given iris code.

Because of possible cyclovergence of the eye in its orbit as well as tilting of the head, all iris code comparisons must be performed over a range of relative orientations. The comparison process then becomes a "best of n" test of agreement, and this must be factored into the statistical decision theory that underlies this method of personal identification. Let $f_0(x)$ be the raw density distribution obtained for the Hamming distances between imposters after testing only at a single relative orientation; for example, $f_0(x)$ might be the binomial defined in (22). Then $F_0(x)$, the cumulative of $f_0(x)$ from 0 to x, becomes the probability of making a False Accept in such a test when using Hamming distance criterion x:

$$F_0(x) = \int_0^x f_0(x)dx \tag{31}$$

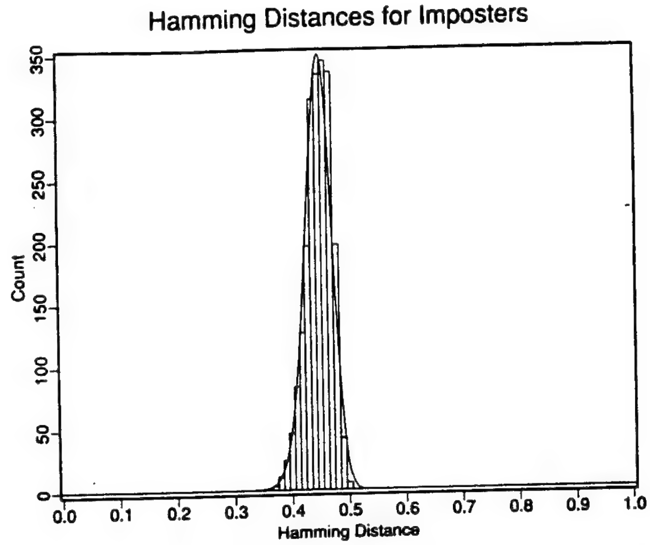

Fig. 9. Hamming distances between unrelated iris codes, allowing for $n = 7$ different degrees of eye or head tilt. Solid curve is (34).

or, equivalently,

$$f_0(x) = \frac{d}{dx}F_0(x). \tag{32}$$

Clearly, then, the probability of *not* making a false accept when using criterion x is $1 - F_0(x)$ after a single test, and it is $[1 - F_0(x)]^n$ after carrying out n such tests independently at n different relative orientations. It follows that the probability of a False Accept after a "best of n" test of agreement, when using criterion x, is

$$F_n(x) = 1 - [1 - F_0(x)]^n \tag{33}$$

and the expected density $f_n(x)$ associated with this cumulative is

$$\begin{aligned} f_n(x) &= \frac{d}{dx}F_n(x) \\ &= nf_0(x)[1 - F_0(x)]^{n-1}. \end{aligned} \tag{34}$$

Fig. 9 shows the distribution of Hamming distances obtained from 2064 pairwise comparisons among the same set of unrelated iris codes as was used in Fig. 6, but allowing for $n = 7$ different relative orientations of the eye. The distribution is biased toward a lower mean Hamming distance of $\mu = 0.450$, since only the best level of agreement after all seven rotations (i.e., the smallest Hamming distance) is kept and registered as the degree of match. The solid curve in Fig. 9 is a plot of (34), using as its $f_0(x)$ term the binomial density distribution specified earlier in (22) and plotted in Figure 6, and using the cumulative of this as its $F_0(x)$ term.

C. Authentics' Hamming Distances

Fig. 10 shows the distribution of Hamming distances computed between 1,208 pairs of different images of given irises ("authentics"). Different images of the same iris never yield a Hamming distance of zero, because of variations in the Subject's angle of gaze, degree of eyelid occlusion, specular

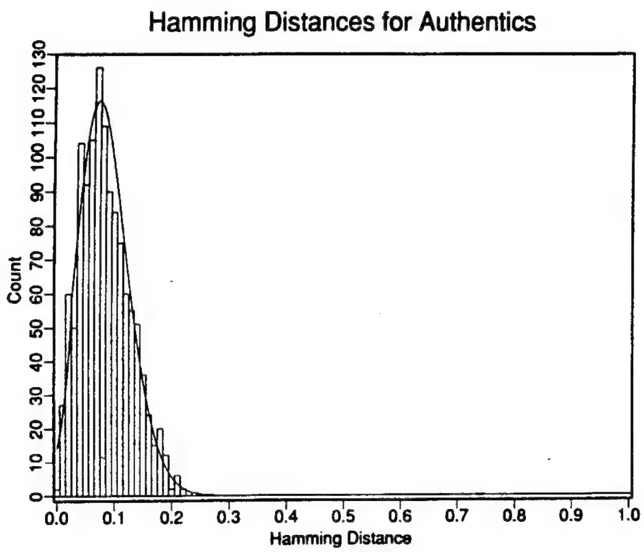

Fig. 10. Hamming distances between pairs of different iris codes for each given iris, allowing for $n = 7$ different degrees of eye or head tilt.

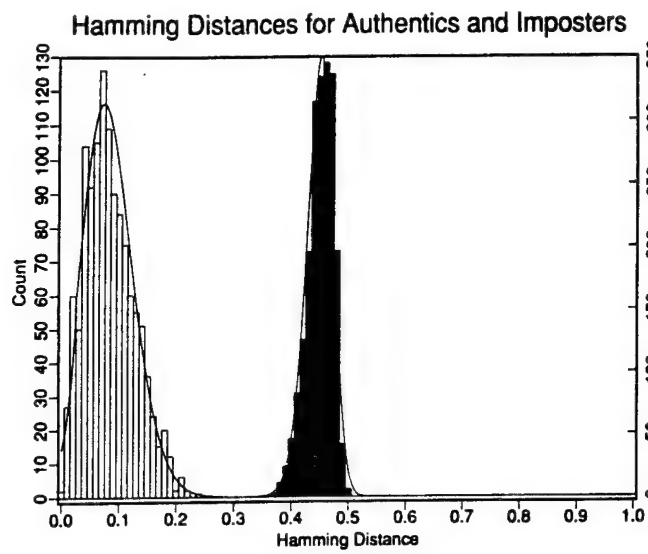

Fig. 11. Hamming distances for authentics and imposters, combined from Figs. 9 and 10.

reflections from the cornea or corrective lenses, random silhouettes of the eyelashes upon the iris, and light-driven as well as uncontrolled oscillations in pupillary dilation ("hippus") which cause some folding and unfolding of iris tissue that would not be captured by the homogeneous rubber sheet model. Nonetheless, these Hamming distances (again with 7 possible relative orientations of the eye) are clearly substantially smaller than those seen in Fig. 9 for imposters. This distribution has a mean of $\mu = 0.084$ and standard deviation $\sigma = 0.0435$. The solid curve plots a binomial as defined previously in (22) but with $p = 0.084$, and $N = 41$ chosen in order to match the observed σ since the standard deviation of a binomial distribution is $\sigma = \sqrt{pq/N}$ where $q = 1 - p$. Continuous interpolation of these binomial distributions, as well as estimation of their factorial terms, was done by Stirling's approximation which errs by less than 1% for $n \geq 9$:

$$n! \approx e^{n \ln(n) - n + \frac{1}{2} \ln(2\pi n)}. \tag{35}$$

D. Equivalent Bernoulli Trials

The distributions of Hamming distances for 2,064 pairwise comparisons of "imposters" (summed across pairwise unrelated iris codes), and for 1 208 pairwise comparisons of "authentics" accumulated separately, are shown together for comparison in Fig. 11. They are clearly well separated, with no empirical overlap and with no observations whatever falling in the region of 0.25 to 0.35 Hamming distance. These superimposed density distributions should be compared with Fig. 7, which represented the classic two-choice decision problem from statistical decision theory.

Each bit in an iris code is a random variable, and thus comparisons between iris codes are comparisons between ensembles of random variables. We have seen that on average, when comparing two iris codes obtained at different times from the same ("authentic") iris and making provision for possible head/eye tilt, any pair of corresponding bits have a probability of 0.084 of not matching. Similarly, we have seen that with the same provision any pair of corresponding bits in two iris codes computed from different irises ("imposters"), have a probability of 0.450 of not matching.

Asking whether a given pair of iris codes were generated by the same iris, or by different irises, is then formally equivalent to the task of discovering to which of two possible classes a given coin belongs. For one type of coin the probability of heads is $p = 0.084$, and for the other type it is $p = 0.450$; and the method for finding out which one it is, is to toss the coin many times. Needless to say, sufficiently many tosses could resolve the question about which type of coin it was with enormously high confidence. The shapes of the two distributions shown in Figure 11 would have been expected using about 480 tosses of the $p = 0.450$ coin, and using about 40 tosses of the $p = 0.084$ coin, respectively, in each run of trials.

E. Decision Confidence Levels

The Bernoulli representation noted above for this pattern recognition task clarifies the calculation of confidence levels associated with any decision, including extrapolation of confidence levels into the region between the two distributions where no Hamming distances were observed empirically. As specified in (23)–(26), the conditional probabilities of personal identity or nonidentity given a particular observation can be calculated as the cumulative integrals under the two density distributions, taken from opposite directions up to whatever Hamming distance was observed. More generally, for any given operating choice of Hamming distance criterion, the latent probabilities of the two types of errors can be calculated by evaluating these cumulative integrals up to the chosen operating criterion.

Empirically, comparisons of iris codes computed from the available database of eye images produced no Hamming distances in the range of 0.25 to 0.35, so the use of any criterion in this range would produce 100% correct performance. However, the natures of the two distributions seen in

TABLE I
PERFORMANCE TABULATED AS ERROR PROBABILITIES FOR SEVERAL DECISION CRITERIA

	Performance	
HD Criterion	Odds of False Accept	Odds of False Reject
0.25	1 in 13.5 billion	1 in 1490
0.26	1 in 2.04 billion	1 in 2660
0.27	1 in 339 million	1 in 4850
0.28	1 in 60 million	1 in 9000
0.29	1 in 12 million	1 in 17100
0.30	1 in 2.4 million	1 in 32800
0.31	1 in 603000	1 in 64200
$\boxed{0.32}$	$\boxed{1 in 151000}$	$\boxed{1 in 128000}$
0.33	1 in 39800	1 in 260000
0.34	1 in 11500	1 in 536000
0.35	1 in 3630	1 in 1.12 million

Figure 11 and described by (22) and (34), allow us to calculate theoretical probabilities for False Accept and False Reject over this range. These probabilities are tabulated in Table 1. As the operating criterion is increased, the theoretical probability of a False Accept of course increases, while that of a False Reject decreases. The cross-over error rate occurs at a Hamming distance criterion of about 0.321, at which point both the False Accept error rate and the False Reject error rate are, theoretically, one in 131 000. This cross-over error rate suggests adopting a Hamming distance close to 0.32 as a balanced operating criterion, although of course more conservative or more liberal decision criteria may be more suitable for different applications. Any such criterion is easily implemented, with performance consequences as listed in Table I.

Finally, it is interesting to examine the posterior confidence levels associated with "typical" decisions for accepting an authentic, and for rejecting an imposter. The means of the two distributions in Fig. 11 indicate typicality. In the typical imposter comparison, which generates a Hamming distance of 0.45 after the "best of n" provision for eye rotation or head tilt, the confidence with which the subject is rejected (given this observation) corresponds to a conditional false reject probability one in $10^{9.6}$, or one in 4 billion. In the typical authentic comparison, which generates a Hamming distance of only 0.084, the confidence with which the Subject is accepted (given this observation) corresponds to a conditional false accept probability of one in 10^{31}.

F. Ergonomics, Robustness to Noise, and Imaging Factors

In many respects, the iris of the eye is inherently difficult to image at a comfortable "social" distance (e.g., several feet from a mounted video camera). It is a small tissue only 11 mm in diameter, and hence optical zoom is required, which creates problems of target motion amplification and limited depth of field for focus. More critical even than these limitations of spatial resolution is the limitation of grey-scale resolution, since without appropriate gain control of the video signal, many very darkly pigmented irises tend to be digitized flatly into only the lowest few states of an 8-bit A-to-D converter and thus reveal little structure. A further reason that spatial resolution is less of a challenge than grey-scale resolution is because the upper roll-off frequency of the multi-scale bandpass 2-D Gabor encoders can be equated to a "blur circle" always larger than three pixels in diameter, which effectively makes any spatial resolution sharper than this irrelevant. Significant parts of the multiscale iris code are based on analysis of the coarser modulations of this mottled tissue; indeed, some of the 2-D Gabor encoders that are deployed subtend as much as a 70° angle around the pupil. In addition to these issues of resolution, a further challenge arises from the fact that unpredictable amounts of the iris may be occluded by eyelids or corrupted by random silhouettes of the eyelashes.

All of these factors contribute to the observation that different images of the same eye at different times may generate iris codes that disagree in as many as 25% of their bits (the highest observed Hamming distance in Fig. 10, for "authentics"). This percentage would be the net result, for example, if only half of the bits were deterministic and matched perfectly, while the entire other half were completely random and hence agreed just by chance half the time, yielding an overall agreement of 75% and thus a 0.25 normalized Hamming distance. The robustness of the present recognition method under such high levels of pattern degradation, noise, and inherent imaging limitations, is only possible because of the high statistical complexity associated with the myriad degrees-of-freedom in the iris signal. It is the consequent narrowness of the distribution of Hamming distances for unrelated eyes (the "Imposters" black distribution shown in Figure 11) that makes any Hamming distance significantly lower than 0.35 virtually impossible to achieve from independent random processes, i.e., unrelated eye images. Thus, the hypothesis of independence can be strongly rejected over all but a narrow range of possible Hamming distances.

It is perhaps illuminating that at the "cross-over" Hamming distance of 0.321, at which point confidence against both types of errors is better than 1 in 10^5, the level of image degradation or mismatch that is tolerated would be equivalent to obscuring fully two-thirds of the iris (producing just chance 50% agreement among those bits) while finding complete agreement among the remaining one-third of the bits. This extreme example illustrates the robustness against occlusion and noise that can be achieved by converting a pattern recognition problem into a test of statistical independence with a sufficiently large number of degrees-of-freedom.

G. Speed of Decision Making

The Bernoulli trial XOR formulation of the decision problem allows us to exploit the 32-bit architecture of a CPU for 16-fold parallelization. Since iris code comparisons are fully vectorizable bitwise, they can be implemented in parallel in single-cycle logic at the register level using 16-bit integer XOR. As a result, on a RISC general-purpose CPU any "presenting" iris code can be compared exhaustively against a large database of stored codes in search of a match at the rate of about 4 000 per second. (This clocked rate includes significant overhead due to complete iris code transfers, as well as table look-up to convert 16-bit integer XOR outcomes into running

sums of Hamming distance.) With dedicated hardware, fuller vectorization can be achieved and a further 40 000-fold speed-up in recognition is now possible. Since the decision process, including the calculation of confidence levels, relies only on computing the logical XOR vector between two iris codes comprising 2 048 bits, conventional SSI devices that have been available for decades at negligible cost offer the basis for immediate parallel implementation. For example, the simple 74F86 integrated circuit contains four independent XOR gates that can be clocked at 80 megahertz. Thus, a 32 x 32 array of 74F86 ICs (or a single equivalent dedicated gate array) could in principle execute comparisons and decisions at the rate of 160 million complete iris codes per second, if exhaustive database searches were required and if such databases existed.

Because of the speed of decision-making made possible by the commensurability of iris codes, it is not even necessary in this method for a Subject to make any claims about his identity (e.g., by entering a password, PIN, or swiping a card) that the biometric comparison then merely confirms or disconfirms. Rather, here he only needs to present his eye to the camera, and his identity is rapidly and automatically *determined* without any further interaction, by exhaustive search through a database that might be extremely large. As Shakespeare conveyed it much less mechanically in *The Merchant of Venice* (Act I, Scene 1), in the tradition of conceiving the eyes as windows to the soul, "Sometimes from her eyes I did receive fair speechless messages."

VI. Conclusion

Aristotelian philosophy held that the $\epsilon\iota\delta o\varsigma$ (ādos, distinguishing essence) of something resided in that quality which made it different from everything else. When we need to know with certainty who an individual is, or whether he is who he claims to be, we normally rely either upon something that he uniquely possesses (such as a key or a card), something that he uniquely knows (such as a password or PIN), or a unique biological characteristic (such as his appearance). Technologically the first two of these criteria have been the easiest to confirm automatically, but they are also the least reliable, since (in Aristotelian terms) they do not necessarily make this individual different from all others. Today, we hold that the uniqueness of a person arises from the trio of his genetic genotype, its expression as phenotype, and the sum of his experiences. For purposes of rapid and reliable personal identification, the first and third of these cannot readily be exploited: DNA testing is neither real-time nor unintrusive; and experiences are only as secure as testimony. The remaining unique identifiers are phenotypic characteristics. It is hard to imagine one better suited than a protected, immutable, internal organ of the eye, that is readily visible externally and that reveals random morphogenesis of high statistical complexity.

Acknowledgment

The author is grateful to Dr. C. Downing for invaluable assistance; to Dr. L. O. Harvey, Jr., and D. A. Pollen, M.D., for useful criticism; and to Le. Flom M.D. and A. Safir M.D. for providing the large photographic database of eye images on which this analysis was partially based.

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John G. Daugman received both the B.A. and Ph.D. degrees at Harvard University.

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Dr. Daugman is the author of about 40 publications in these fields, and he serves as Associate Editor of the journals IEEE Transactions on Pattern Analysis and Machine Intelligence; IEEE Transactions on Neural Networks; *Brain Research: Cognitive Brain Research*; and he is a member of the Executive Board of *Network: Computation in Neural Systems*. In 1988, he was awarded the Presidential Young Investigator Award by the U.S. National Science Foundation. In 1989, he became the inaugural holder of the Toshiba Endowed Chair in Computer Science at the Tokyo Institute of Technology, and in 1991, he was elected a Senior Research Fellow of the Faculty of Biology at Cambridge University, where he is a member of King's College and where he now directs research in computational neuroscience.

APPENDIX E

DEFENSE NUCLEAR AGENCY

OPERATIONAL PROCEDURES

FOR BRASSBOARD IV UNIT

DNA BRASSBOARD IV SYSTEM OPERATION:

General: Set up and operation of the Brassboard Proof-of-Concept Identification /Verification (IV) System should be performed by individuals who are familiar with the technical performance of the unit and have received instruction on how to perform the basic procedures for system operation. Personnel operating the system should be familiar with the procedures for configuring the system to perform enrollment, identification, and verification. In the event of any questions or problems, contact IriScan, Inc. at (609) 234-7977, or (800) 333-6777).

1. INITIALIZATION:

A. If unit is not running, connect the power cord. System will automatically boot.

B. After boot-up, turn selector key to ADMIN (fully counterclockwise).

C. Type "Date". Hit "Enter". Enter appropriate date. Hit "Enter".

D. Type "Time". Hit "Enter". Enter appropriate time. Hit "Enter".

NOTE: Updating/checking the system Date and Time may be accomplished any time. It is particularly appropriate if a power failure or fluctuation is suspected.

E. Turn selector key to appropriate operating position.

F. Type "sensekey". Hit "Enter".

G. Make log entry.

2. EVENT RECORDING:

It is suggested that a log be kept describing operation of the system and what actions were taken relative to operation and/or maintenance. It is especially important to keep track of enrollments to maintain continuity of files and to ensure that identifications / verifications continue to be accurate.

Entries should be made to document events out of the norm or when a "Performance Failure" occurs. For example, a log entry should be made if an individual successfully "spoofs" the system by being mistakenly identified as another individual during "IDENTIFY" mode operation, or is mistakenly identified when he / she is not enrolled in the database. Similarly, if an authorized individual (someone who is legitimately enrolled in the system) is "rejected" (i.e. receives a reject signal on three (3) successive attempts), this fact should be entered in the Data Collection Form with possible explanation as to what may have caused the failure (e.g. individual wore glasses and had difficult time focusing or removing "light reflection" from their glasses. This is particularly true if the glasses are overly scratched or dirty.

In contrast to the "by exception" method for the Data-collection Form, enrollments should be logged on the Enrollment Record Form in detail each time an iris is enrolled (normally two for each individual, right eye first, followed by the left eye.)

3. ENROLLMENT PROCEDURES:

CAUTION: BEFORE ATTEMPTING TO ENROLL INDIVIDUALS INTO THE SYSTEM, CHECK THE ENROLLMENT FORM TO DETERMINE IF THE INDIVIDUAL IS ALREADY ENROLLED. IF THE INDIVIDUAL IS ENROLLED IN THE DATA BASE, DO NOT RE-ENROLL THEM.

NOTE: ENROLLMENT ON THE BRASSBOARD UNIT CAN ONLY BE ACCOMPLISHED WITH A KEYBOARD, MONITOR, AND REMOTE CONTROL BOX PROPERLY CONNECTED AS PERIPHERALS TO THE UNIT.

Persons being enrolled on the brassboard system should receive verbal instructions and a demonstration of the enrollment process prior to being enrolled into the master database. Enroll without glasses if at all possible. Subsequent identifications / verifications may be with or without glasses at the subject's preference. Each test subject should demonstrate familiarity with the equipment and enrollment process before being enrolled. The familiarity demonstration should include a requirement for the individual to demonstrate his / her ability to locate (i.e."find") their eye(s) in the center of the imaging aperture, acquire and maintain satisfactory image focus by use of the eye image feedback feature, and maintain a stable position for sufficient time to acquire the minimum number of images required for enrollment. This process should be repeated for each eye, starting with the individual's "strong" or preferred eye. In the event both eyes are not capable of being

enrolled (e.g. person has only one eye or is unable to see in one eye), the test log should note the reason for not enrolling both eyes.

The procedures for enrollment are as follows:

A. Provide verbal description of the enrollment process.

B. Demonstrate the enrollment process. (Note: It is not necessary for the operator to actually perform an enrollment in order to demonstrate the process.)

C. Place the system in the Enroll Mode by placing the key switch in the "ENROLL" position.

NOTE: THIS ACTION WILL AUTOMATICALLY TURN ON THE LIGHT SO THE INDIVIDUAL CAN SEE THE IMAGE OF THE EYE IN THE VIEWING APERTURE WHEN PROPERLY ALIGNED.

CAUTION: <u>DO NOT DEPRESS THE REMOTE SWITCH OR LET THE INDIVIDUAL DEPRESS THE START PUSHBUTTON, AS THIS ACTION WILL START THE ENROLLMENT PROCESS PRIOR TO THE INDIVIDUAL BEING PROPERLY TRAINED</u>.

D. Have the individual attempt to locate his eye in the viewing aperture, achieve adequate image focus, and generally, become comfortable with interfacing with the system before starting the next step. Observe the image on the monitor and provide verbal instructions to the individual to assist in achieving acceptable interface with the unit. Inform the subject that movement along the "Z" axis (toward / away from the optical platform) should be performed slowly or in small increments. Point out

the method of using the triangular-shaped light reflection appearing in the pupil to achieve good focus by movement in the "Z" axis to make the reflection as small as possible.

E. Initial False Accept testing (if desired). With the system operating in the identification mode (i.e., key switch in IDENTIFY position), initiate the identification process by depressing the START button. The individual should locate his eye in the center of the imaging aperture and acquire and maintain a sharply-focused image of the presented eye. This process should result in a "REJECT" decision. Have the individual repeat the demonstration with the opposite eye, including the attempt at identification, if not physically prohibited from doing so. Since the individual is not yet enrolled in the Master Database, an attempt to have him identified counts as a valid attempt to cause a Type II error. Results of identification and verification attempts are being recorded on the hard drive; however, the system has no method for differentiating between a valid identification, and a false identification. Therefore, all successful "Spoofing" attempts (those resulting in a False Accept) must be recorded in the test log.

> NOTE: Approximately 10 seconds after an identification, the system will automatically return to the standby mode, and the information on the monitor will be lost. To retain that information until the appropriate log entries can be made, depress the "Pause" button on the keyboard.

F. After completing the process of attempting to spoof the system, place the key switch in the ENROLL position and allow time for the system to load the enroll software. When the screen indicates the presence of video, the unit is ready for enrollment. Have the individual acquire and

maintain a well-focused image of the eye. Observe the monitor for a well-focused image and initiate the enrollment sequence by depressing the pushbutton located on the Remote-Control box. After the unit has acquired the selected number of images (normally three), determine if the Hamming Distance (HD) of the "selected" image is indicative of a high-quality enrollment. Even though the unit has a preset HD to determine acceptable code for enrollment, **the final decision to accept the image remains with the operator.** The operator should strive to achieve the best enrollment possible as indicated by a low HD (less than 0.15, if possible). If, however, a subject has difficulty maintaining good focus or image location, a higher HD (as automatically determined by the software) is acceptable. In practice and under normal operating environments, a highly-experienced operator may evaluate the quality of the enrollment and elect to repeat such enrollment to improve the quality of the stored file by reducing the HD. It is important that the Data Collection Form include any situation where difficulty is experienced during the enrollment process, including the operator's assessment of the possible cause of the difficulty. After the operator determines that the IrisCode is acceptable for enrollment, the operator should complete the enrollment process by following the screen prompts. Just hit "enter" for the prompts which ask for Privilege code.

> **CAUTION:** After entering the administrative data and accepting the information (triggering an automatic update of the temporary database file), you should receive the following screen prompt: "Temporary database updated, update permanent database?" At this prompt, type "Y" if the permanent (Flash Memory) database is to be updated or "N" if not. DO NOT HIT "ENTER" AFTER TYPING YOUR CHOICE. Depressing the "ENTER" key will cause

the system to skip and return to the configuration of ready for enrolling another eye. JUST SELECT "Y" OR "N".

G. After completing enrollment of the individual's first eye, repeat the process for the remaining eye.

NOTE: In the event more than one individual is being enrolled during the same period, the procedures should be repeated for each individual. It is important that each person is provided an opportunity the become familiar with the process and is allowed to acquire and maintain a well-focused image of his eye before performing the enrollment process for test purposes.

H. After completing the enrollment process (for either one or multiple individuals), place the system in the IDENTIFY or VERIFY operating mode. Have the individual(s) who successfully completed the enrollment process attempt to be identified by the system a minimum of FIVE (5) times for each enrolled eye.

4. IDENTIFICATION PROCEDURES:

A. Approach the brassboard unit and adjust the sensor for height.

B. Depress the START button on the front panel.

C. Maintain the image of the presented iris in focus and steady until receiving a visual and audible signal.

D. If rejected (red Reject light and two beeps), repeat the procedure.

E. If rejected a second time, repeat the procedure.

F. Note the results of the identification attempt on the Data Collection Form if any Rejects occur. Write "FALSE REJECT" on the Data Collection Form if three consecutive Rejects occur.

5. VERIFICATION PROCEDURES:

A. Approach the brassboard unit and adjust the sensor for height.

B. On the keyboard, enter the four-digit Personal Identification Number (PIN) of the subject who wishes to be verified.

C. Maintain the image of the presented iris in focus and steady until receiving a visual and audible signal.

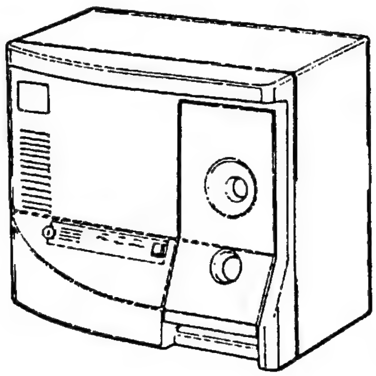
D. If rejected (red Reject light and two beeps), repeat the procedure.

E. If rejected a second time, repeat the procedure.

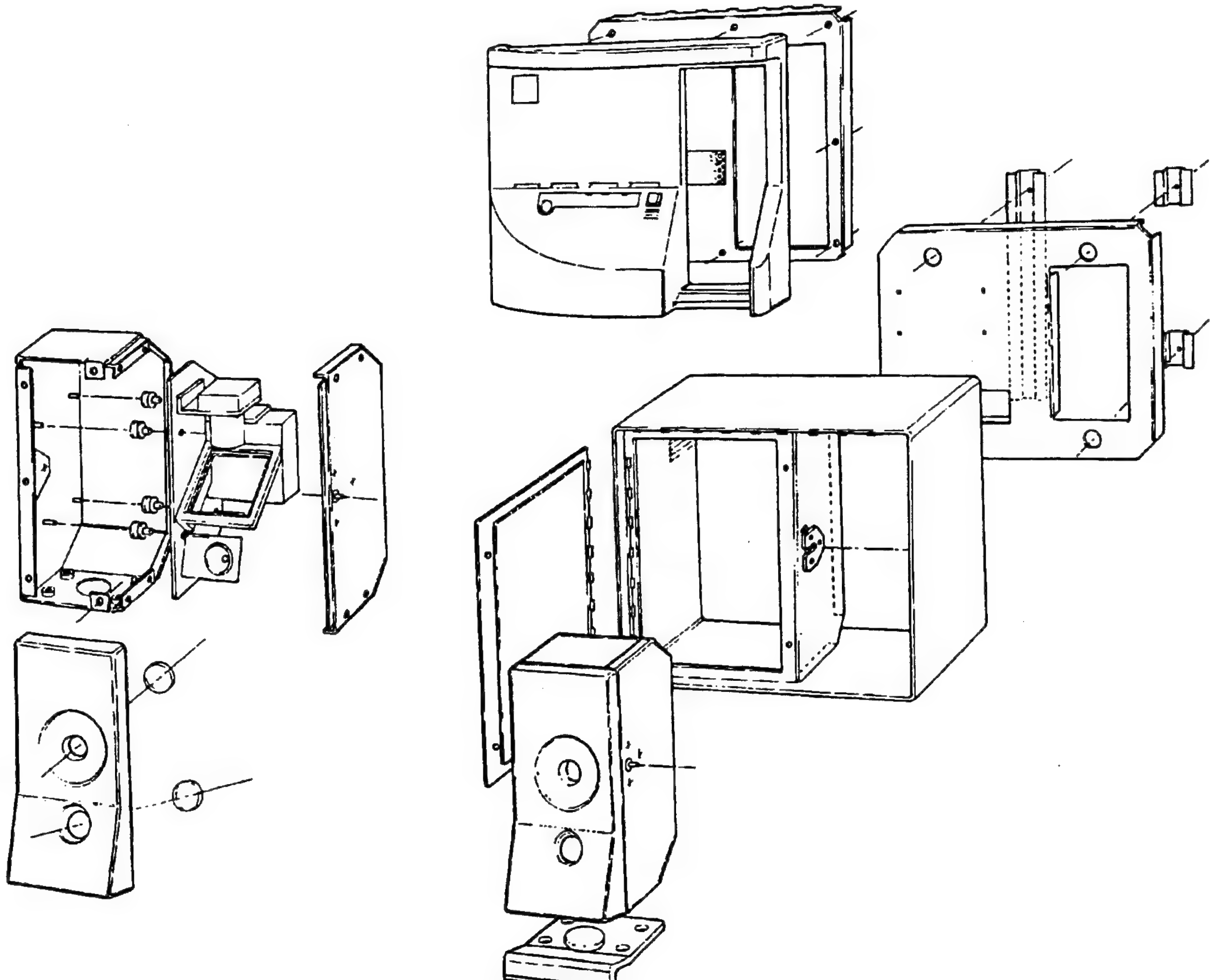
F. Note the results of the procedure on the Data Collection Form if any Rejects occur. Write "FALSE REJECT" on the Data Collection Form if three consecutive Rejects occur.

APPENDIX F

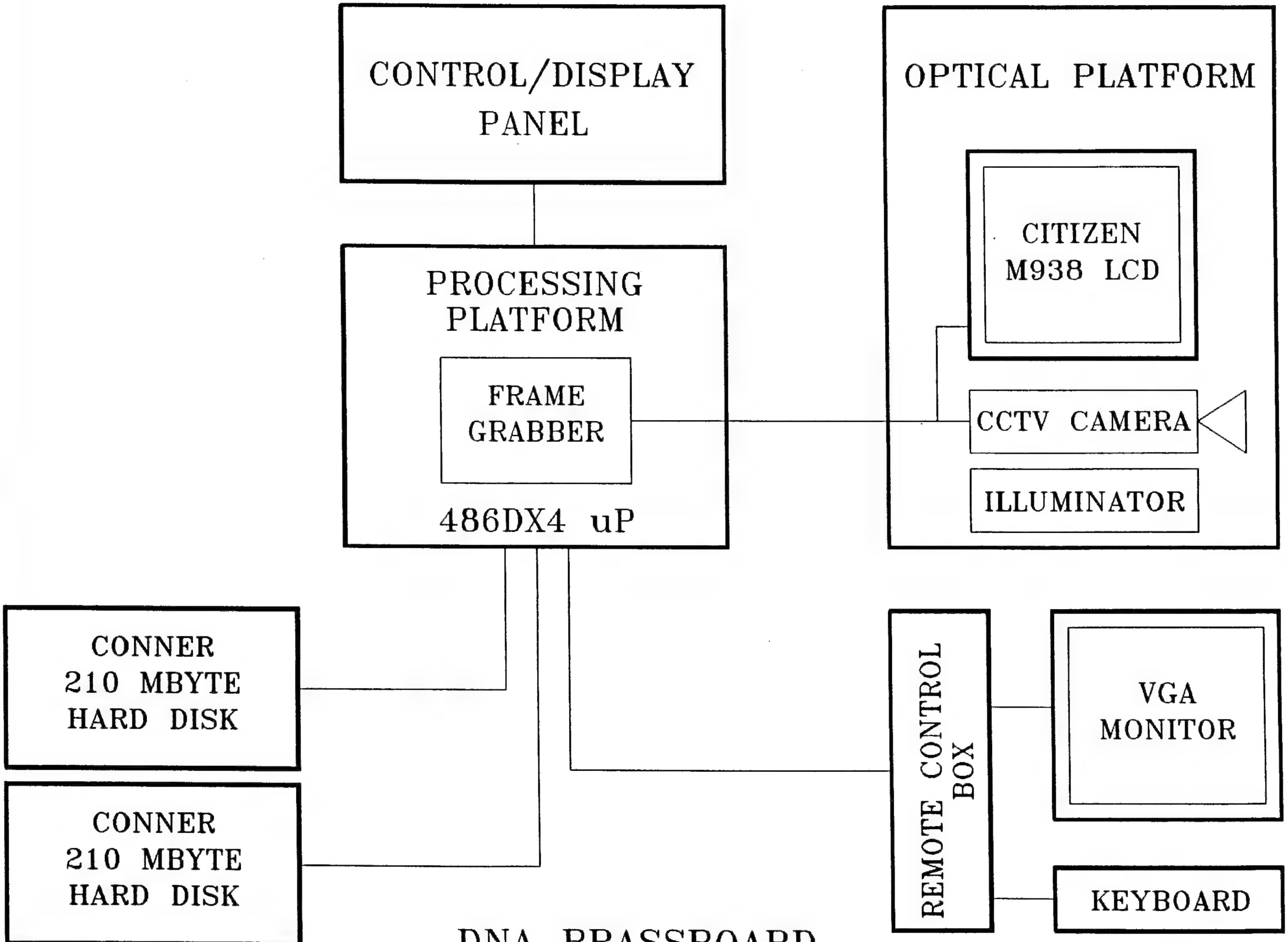
DRAWINGS



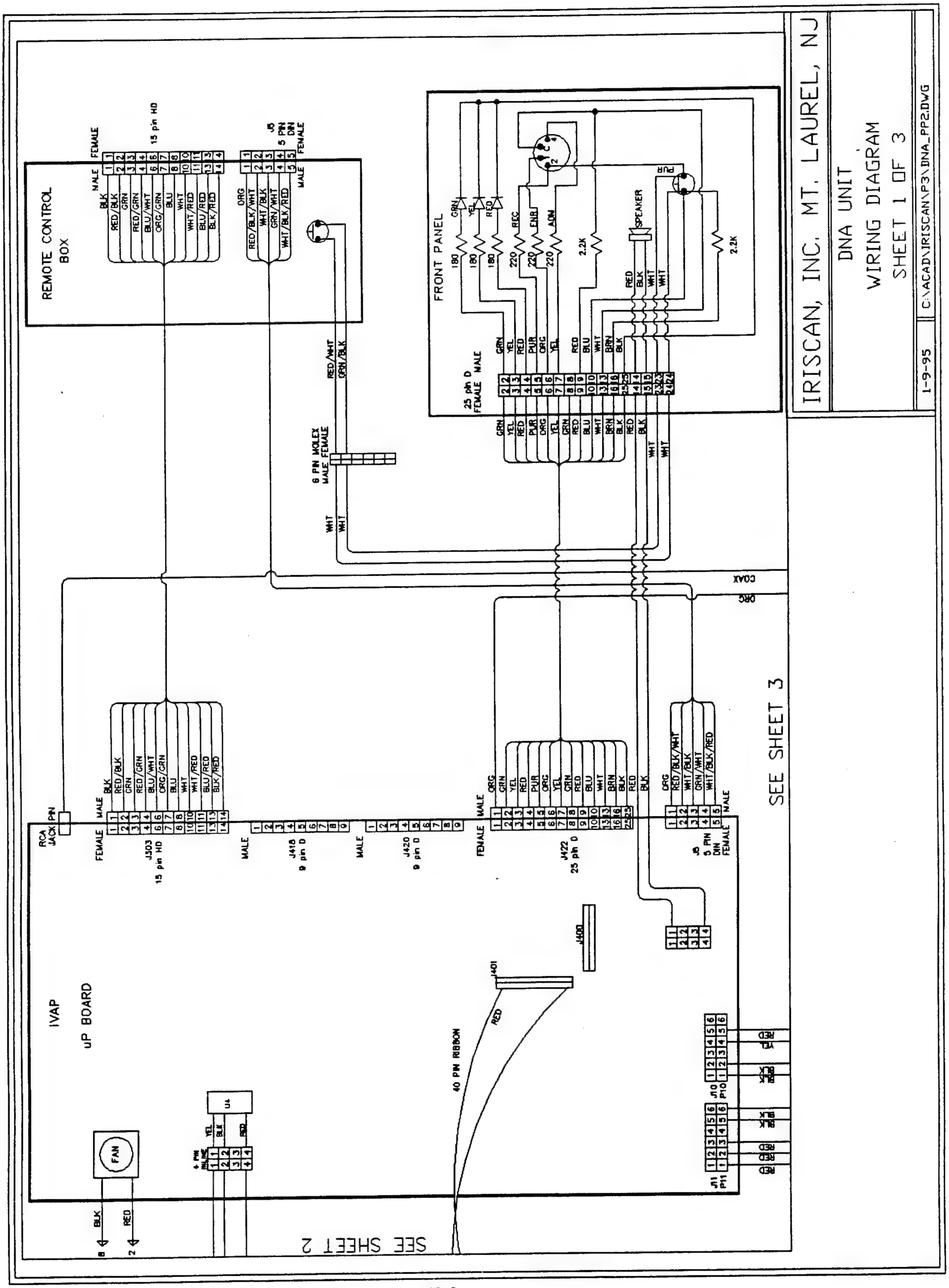
1

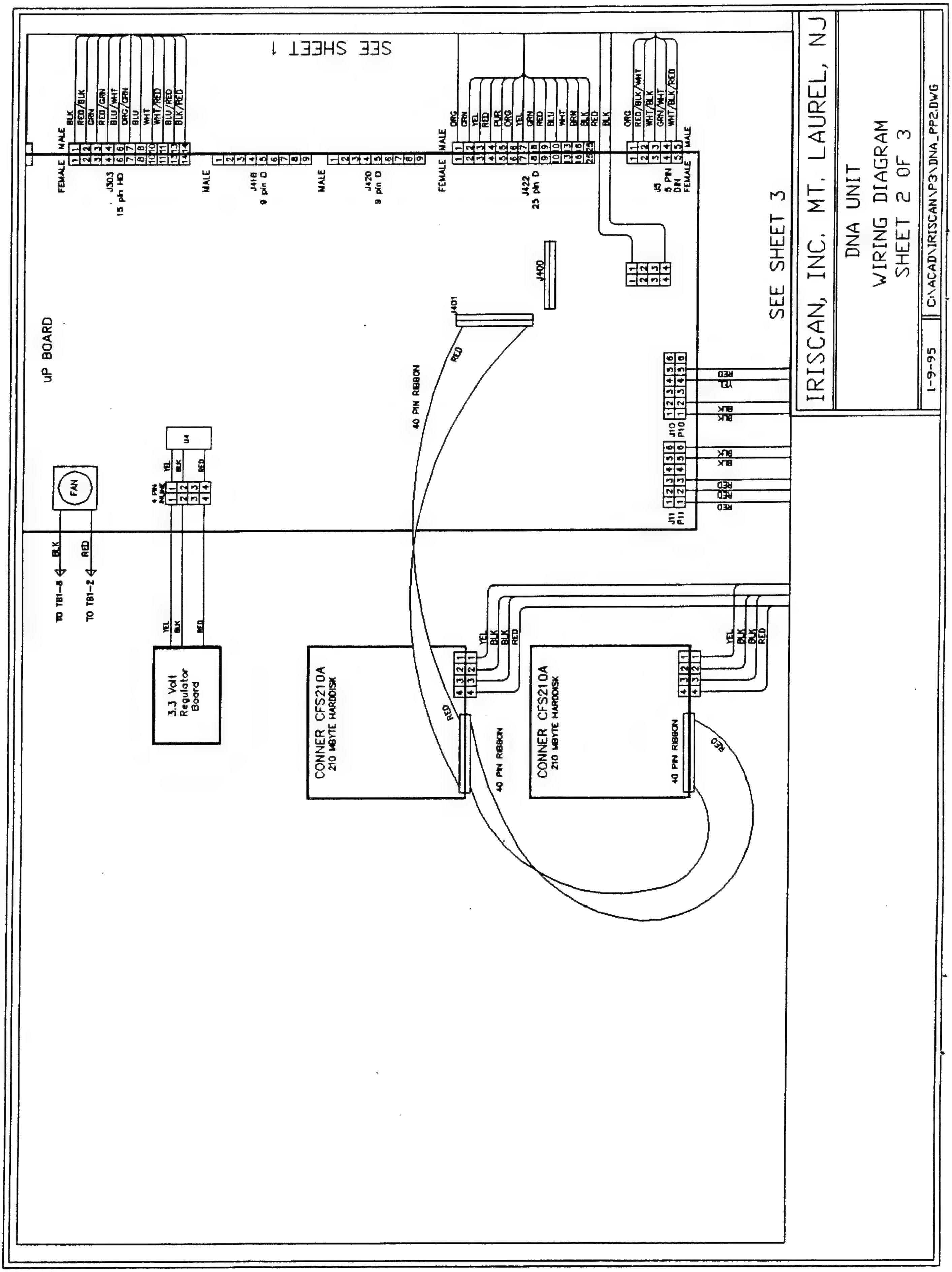


Concept Assembly



DNA BRASSBOARD
SYSTEM BLOCK DIAGRAM


IRISCAN, INC. MT. LAUREL, NJ
DNA UNIT
WIRING DIAGRAM
SHEET 1 OF 3
C:\ACAD\IRISCAN\P3\DNA_PP2.DWG
1-9-95
REMOTE CONTROL BOX
FRONT PANEL
IVAP
uP BOARD
SEE SHEET 3
SEE SHEET 2
40 PIN RIBBON
COAX
ORG
SPEAKER
FAN



IRISCAN, INC. MT. LAUREL, NJ
DNA UNIT
WIRING DIAGRAM
SHEET 2 OF 3
1-9-95
C:\ACAD\IRISCAN\P3\DNA_PP2.DWG
SEE SHEET 1
SEE SHEET 3
uP BOARD
FAN
TO TB1-8
TO TB1-2
3.3 Volt Regulator Board
U4
4 PIN INLINE
CONNER CFS210A
210 MBYTE HARDDISK
CONNER CFS210A
210 MBYTE HARDDISK
40 PIN RIBBON
J401
J400
J303
15 pin HD
J418
9 pin D
J420
9 pin D
J422
25 pin D
J5
5 PIN DIN
J10
P10
J11
P11
FEMALE
MALE
BLK
RED/BLK
GRN
RED/GRN
BLU/WHT
ORG/GRN
BLU
WHT
WHT/RED
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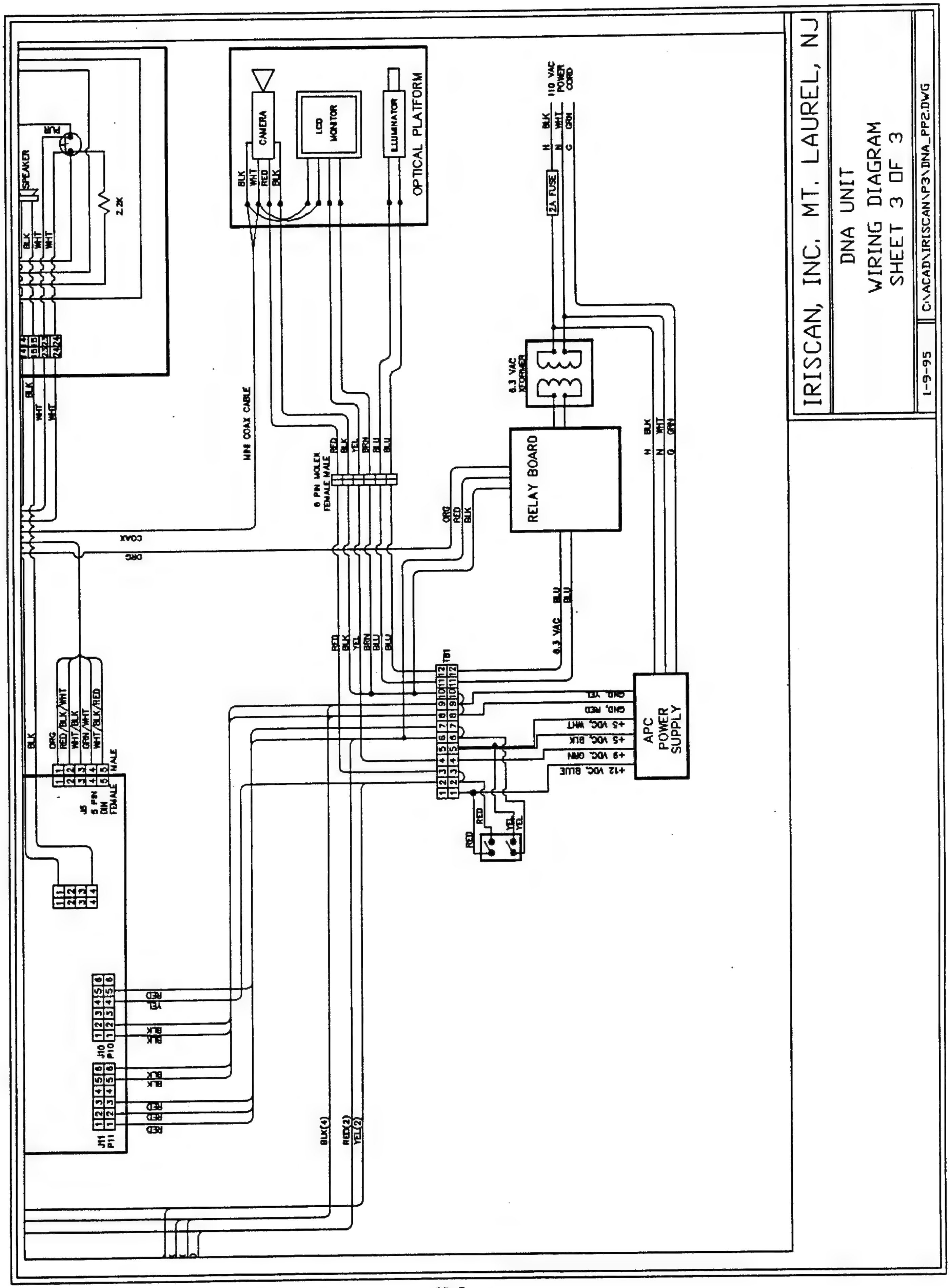
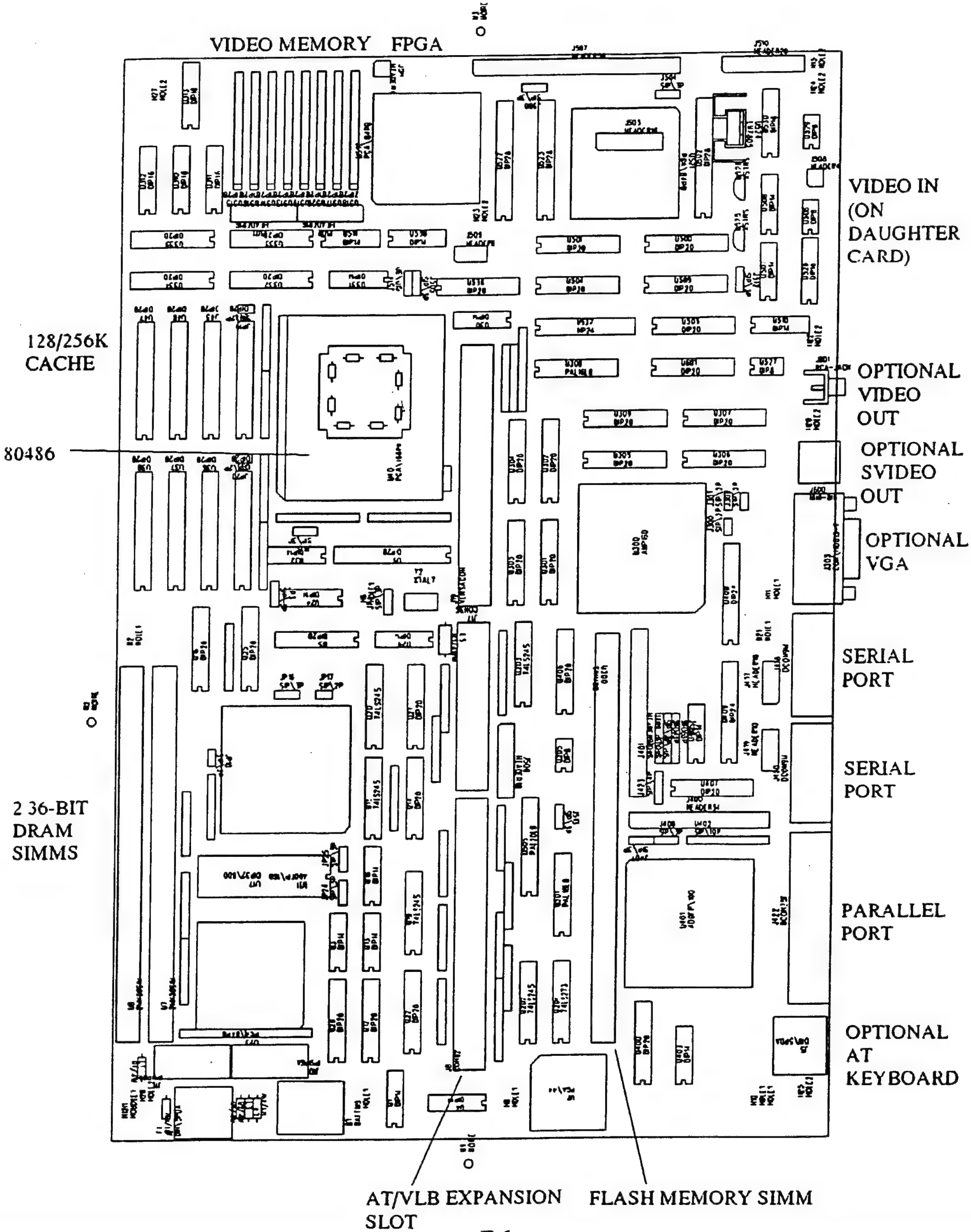
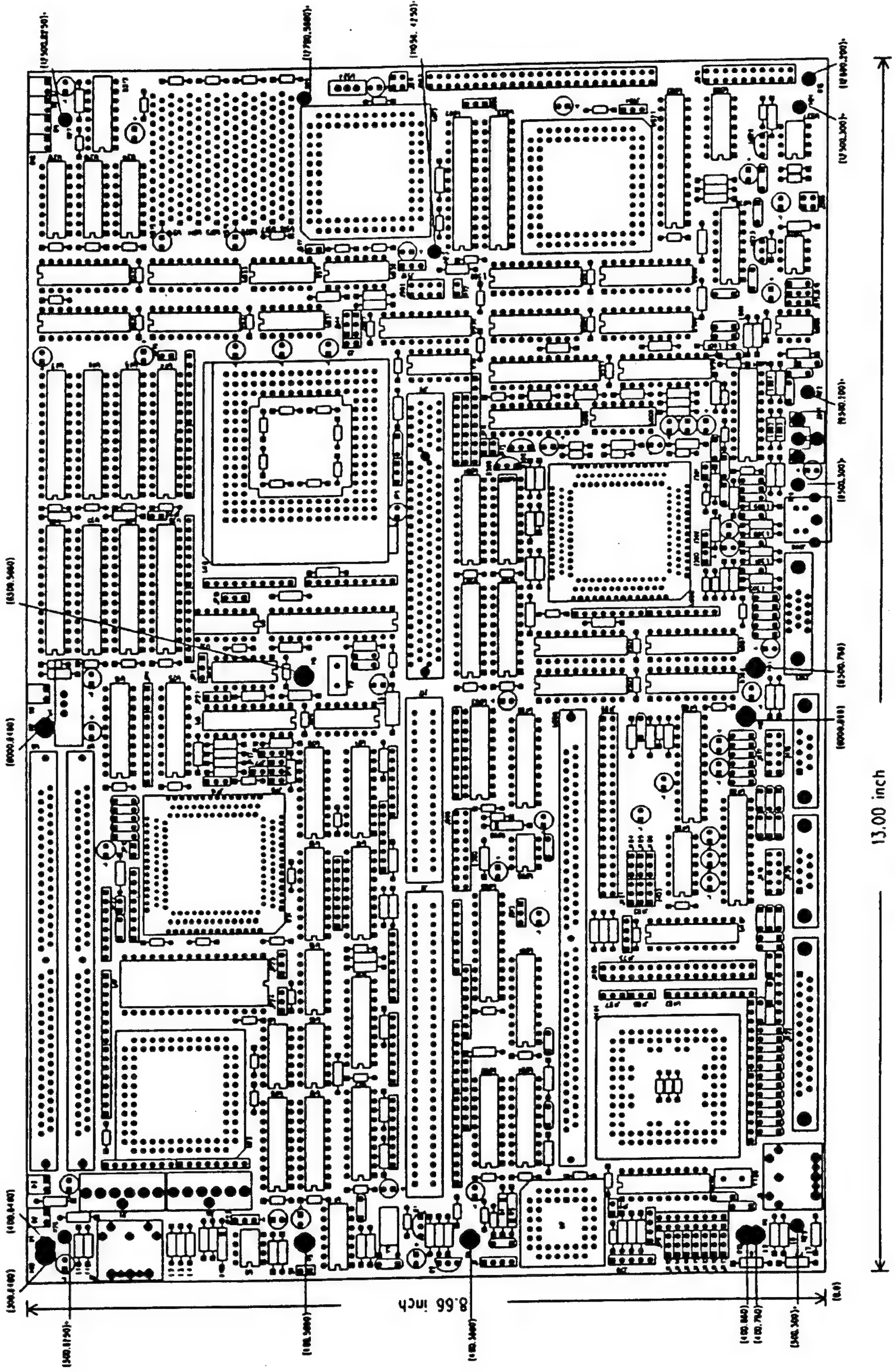
GRN/WHT
WHT/BLK/RED


IRISCAN, INC. MT. LAUREL, NJ
DNA UNIT
WIRING DIAGRAM
SHEET 3 OF 3
C:\ACAD\IRISCAN\P3\DNA_PP2.DWG
1-9-95
OPTICAL PLATFORM
CAMERA
LCD MONITOR
ILLUMINATOR
SPEAKER
2.2K
MINI COAX CABLE
8 PIN MOLEX FEMALE MALE
RELAY BOARD
6.3 VAC XFORMER
2A FUSE
110 VAC POWER CORD
6.3 VAC
TB1
APC POWER SUPPLY
GND, YEL
GND, RED
+5 VDC, WHT
+5 VDC, BLK
+9 VDC, GRN
+12 VDC, BLUE
J5 5 PIN DIN FEMALE MALE
J10 P10
J11 P11
COAX
ORG


VIDEO MEMORY
FPGA
VIDEO IN (ON DAUGHTER CARD)
128/256K CACHE
OPTIONAL VIDEO OUT
80486
OPTIONAL SVIDEO OUT
OPTIONAL VGA
SERIAL PORT
SERIAL PORT
2 36-BIT DRAM SIMMS
PARALLEL PORT
OPTIONAL AT KEYBOARD
AT/VLB EXPANSION SLOT
FLASH MEMORY SIMM



FAB DRAWING

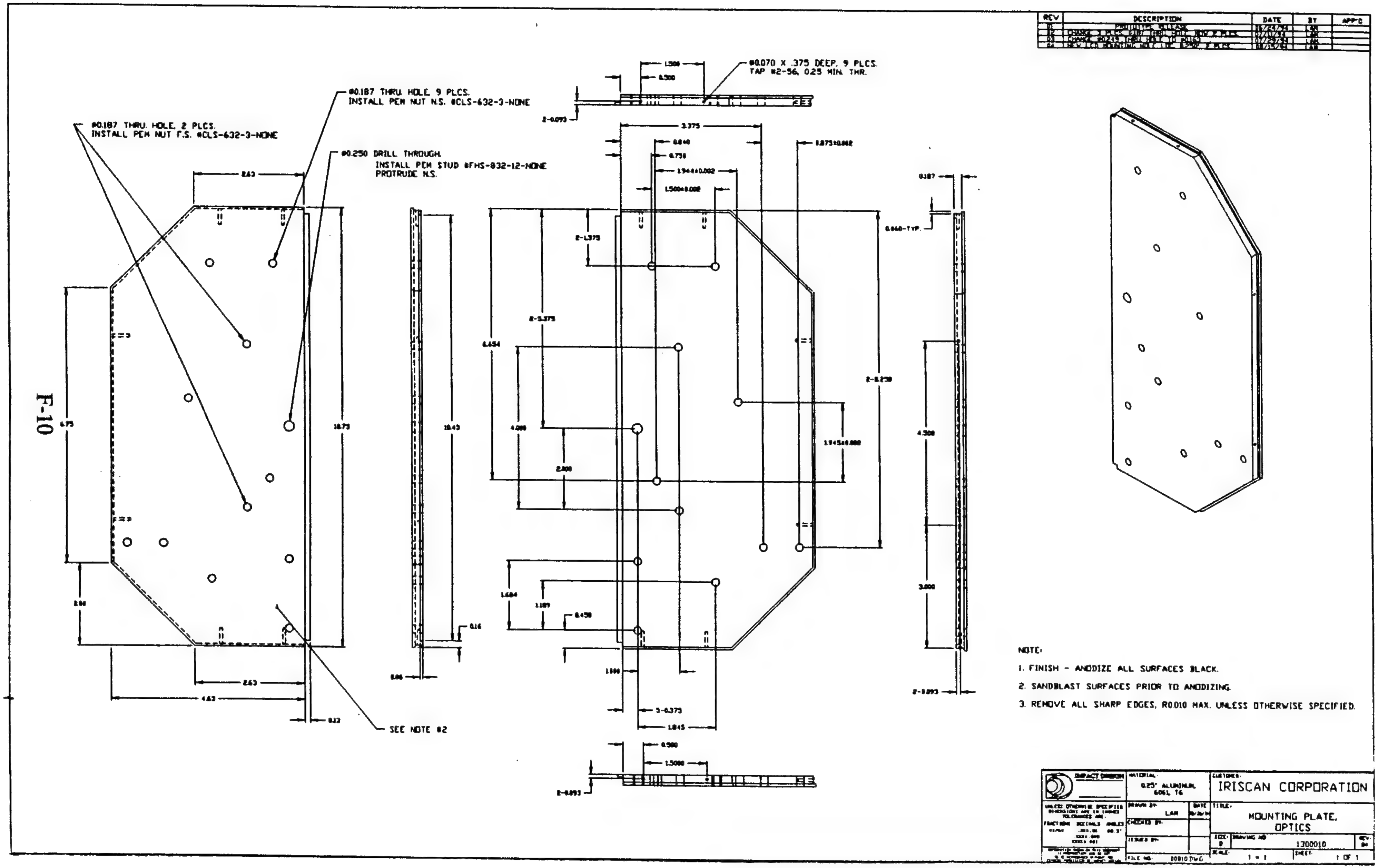
IriScan Incorporated / Iris Scanner Part List

IMPACT DESIGN: PROJECT #940130 / PROTOTYPE RELEASE

DWG #	PART NAME	REVISION	DWG SIZE
010	MOUNTING PLATE, OPTICS	04	D
020	BEAM SPLITTER BRACKET, OPTICS	01	C
030	CAMERA MOUNTING BRACKET, OPTICS	01	C
040	LCD MOUNTING BRACKET, OPTICS	01	C
050	CHASSIS, OPTICS	02	E
060	COVER PLATE, OPTICS	03	D
070	MID-PLANE, SCANNER	02	D
080	OUTER SHELL, SCANNER	01	D
090	SHROUD FRAME, SCANNER	05	D
100	BACK PLANE, SCANNER	01	D
110	CPU DOOR, SCANNER	02	D
120	LARGE HANGER BRACKET	01	B
130	SMALL HANGER BRACKET	01	B
140	I.O. BRACKET, SCANNER	01	B
150	LIGHT PIPE, OPTICS	01	B
160	LIGHT PIPE BRACKET, OPTICS	02	B
170	ANGLE BRACKET, SCANNER	02	B
180	LEFT MOUNTING BLOCK, OPTICS	01	B
190	RIGHT MOUNTING BLOCK, OPTICS	02	B
200	SHROUD, SCANNER	02	E
210	SHROUD, OPTICS	01	C
220	HANDLE, OPTICS	01	B

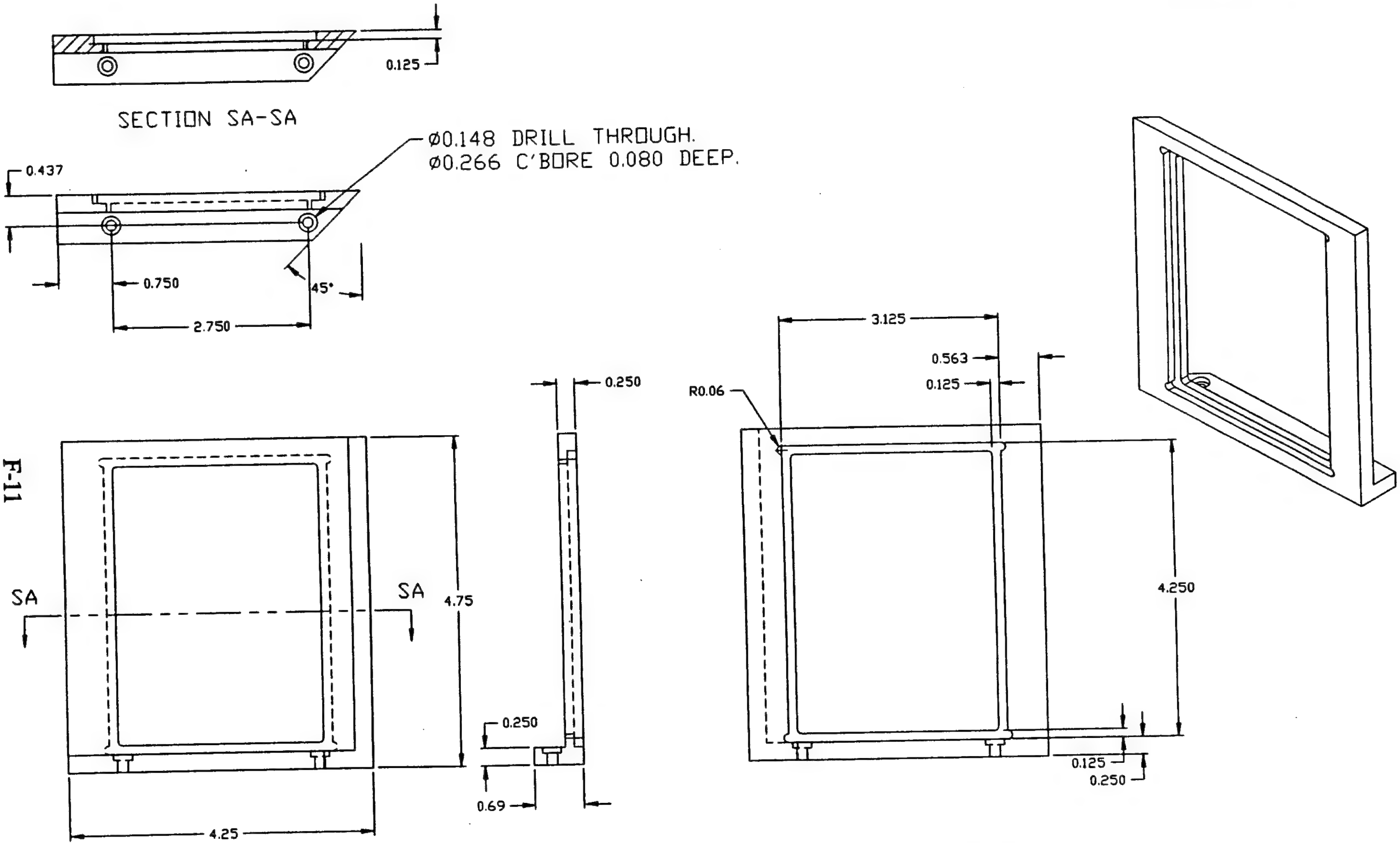
230	CAM, OPTICS	02	B
*240	KEEPER, SCANNER	01	B
250	SHROUD HINGE, SCANNER	01	C
260	FOLLOWER ARM	02	A
270	TRIPOD MOUNT PLATE, OPTICS	01	B
280	FOLLOWER BEARING, CHASSIS	01	A
290	AXIS, OPTICS	01	A

*THIS PART HAS BEEN ELIMINATED.



ø0.070 X .375 DEEP, 9 PLCS.
TAP #2-56, 0.25 MIN. THR.
ø0.187 THRU. HOLE, 9 PLCS.
INSTALL PEM NUT N.S. #CLS-632-3-NONE
ø0.187 THRU. HOLE, 2 PLCS.
INSTALL PEM NUT F.S. #CLS-632-3-NONE
ø0.250 DRILL THROUGH.
INSTALL PEM STUD #FHS-832-12-NONE
PROTRUDE N.S.
SEE NOTE #2
NOTE:
1. FINISH - ANODIZE ALL SURFACES BLACK.
2. SANDBLAST SURFACES PRIOR TO ANODIZING.
3. REMOVE ALL SHARP EDGES, R0010 MAX. UNLESS OTHERWISE SPECIFIED.
REV
DESCRIPTION
DATE
BY
APP'D
PROTOTYPE RELEASE
IMPACT DIMENSION
MATERIAL:
0.25" ALUMINUM, 6061 T6
CUSTOMER:
IRISCAN CORPORATION
TITLE:
MOUNTING PLATE, OPTICS
DRAWN BY: LAM
CHECKED BY:
ISSUED BY:
SIZE: D
DRAWING NO: 1300010
REV: 04
SCALE: 1 = 1
SHEET: 1 OF 1

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	06/27/94	LAM	



NOTE:

1. FINISH - ANODIZE ALL SURFACES BLACK.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.

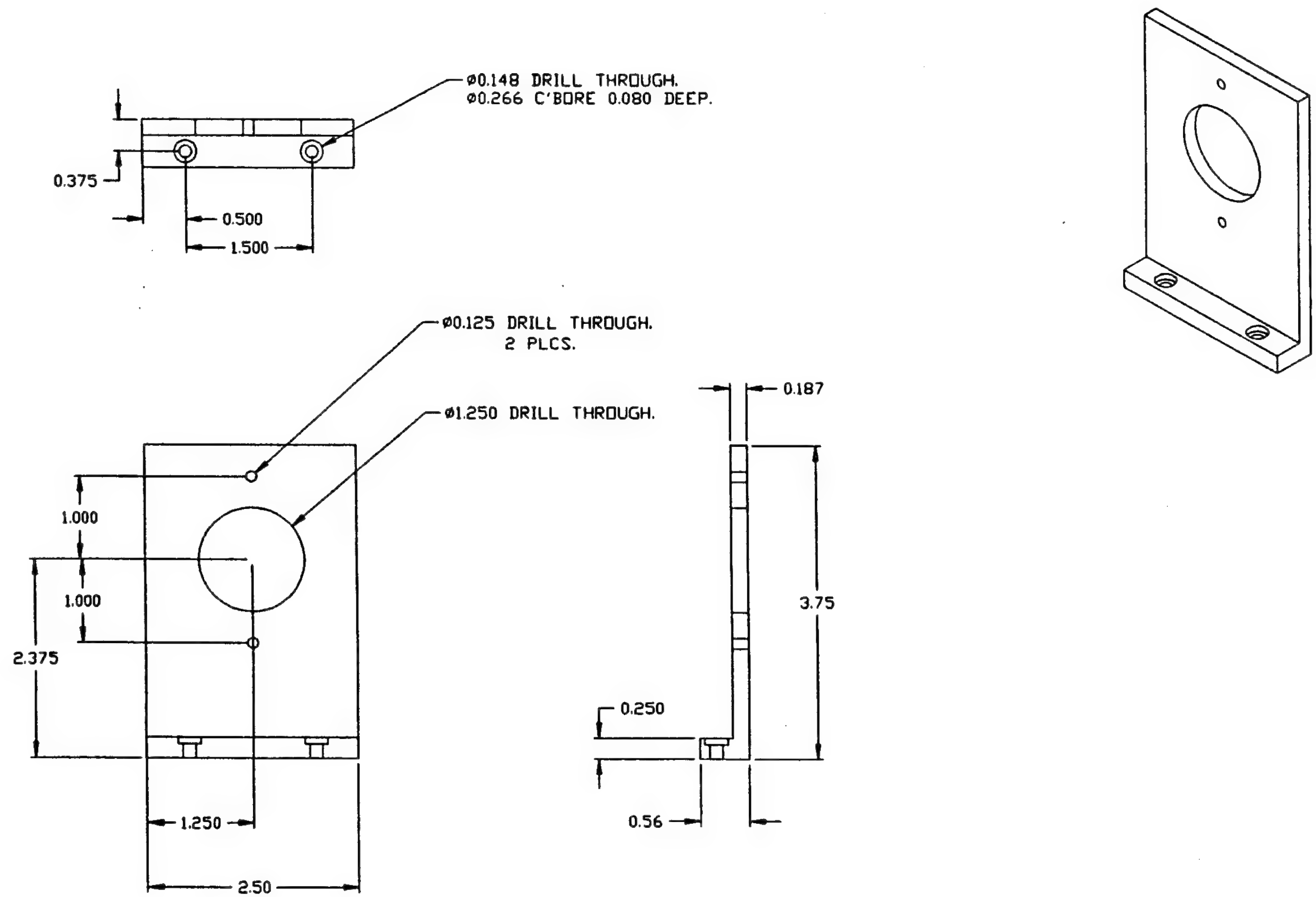
IMPACT DESIGN

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

FRACTIONS	DECIMALS	ANGLES
±1/64	.XX± .01	±0.5°
	.XXX± .005	
	.XXXX± .001	

MATERIAL:	ALUMINUM, 6061, T6
DRAWN BY:	LAM
DATE	06/01/94
CHECKED BY:	
ISSUED BY:	
FILE NO	00020.DWG
CUSTOMER:	IRISCAN INCORPORATED
TITLE:	BEAM SPLITTER BRACKET, OPTICS
SIZE:	C
DRAWING NO:	1300020
REV:	01
SCALE	1 = 1
SHEET:	1 OF 1

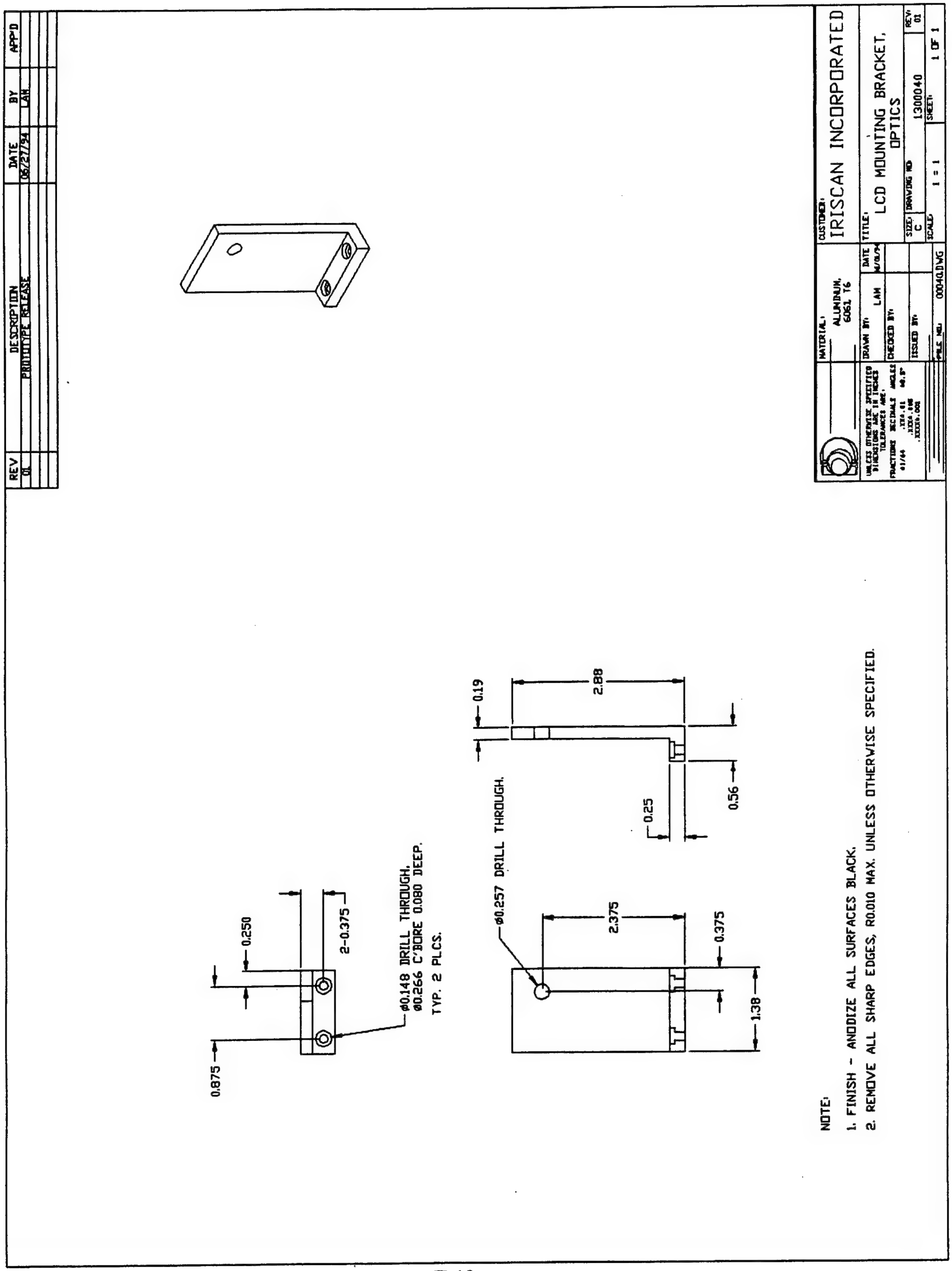
REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	06/27/94	LAM	

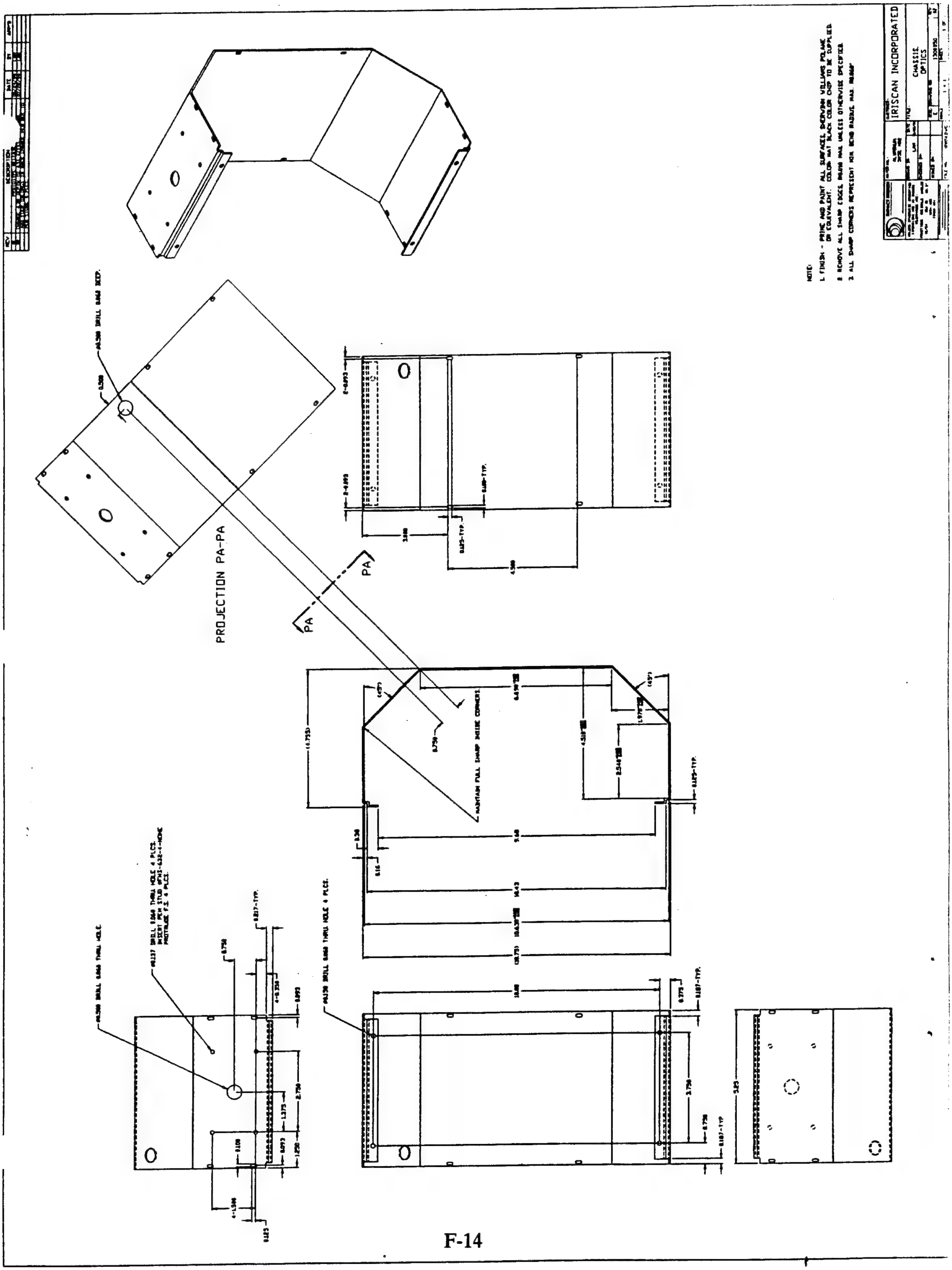


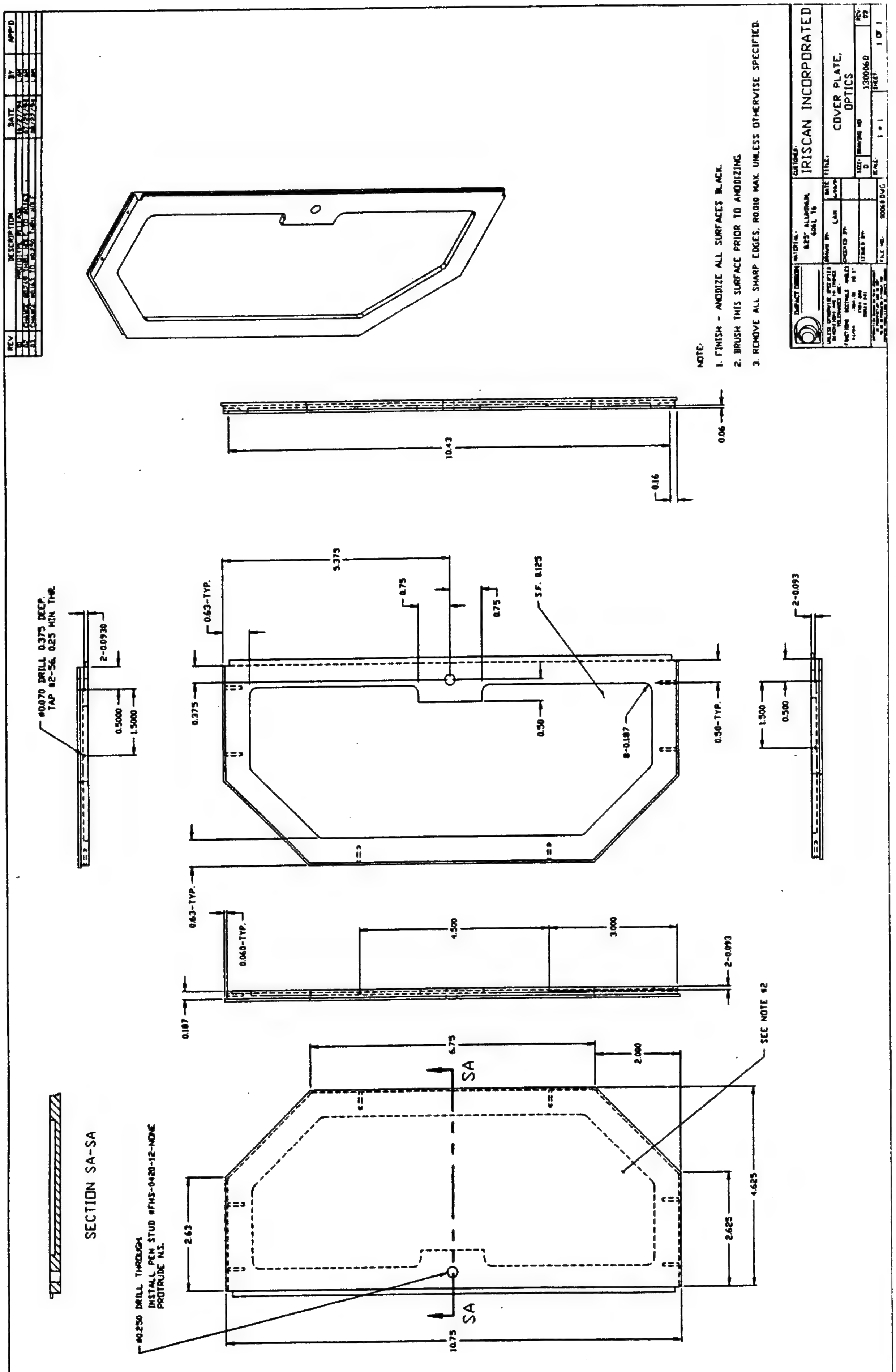
NOTE:

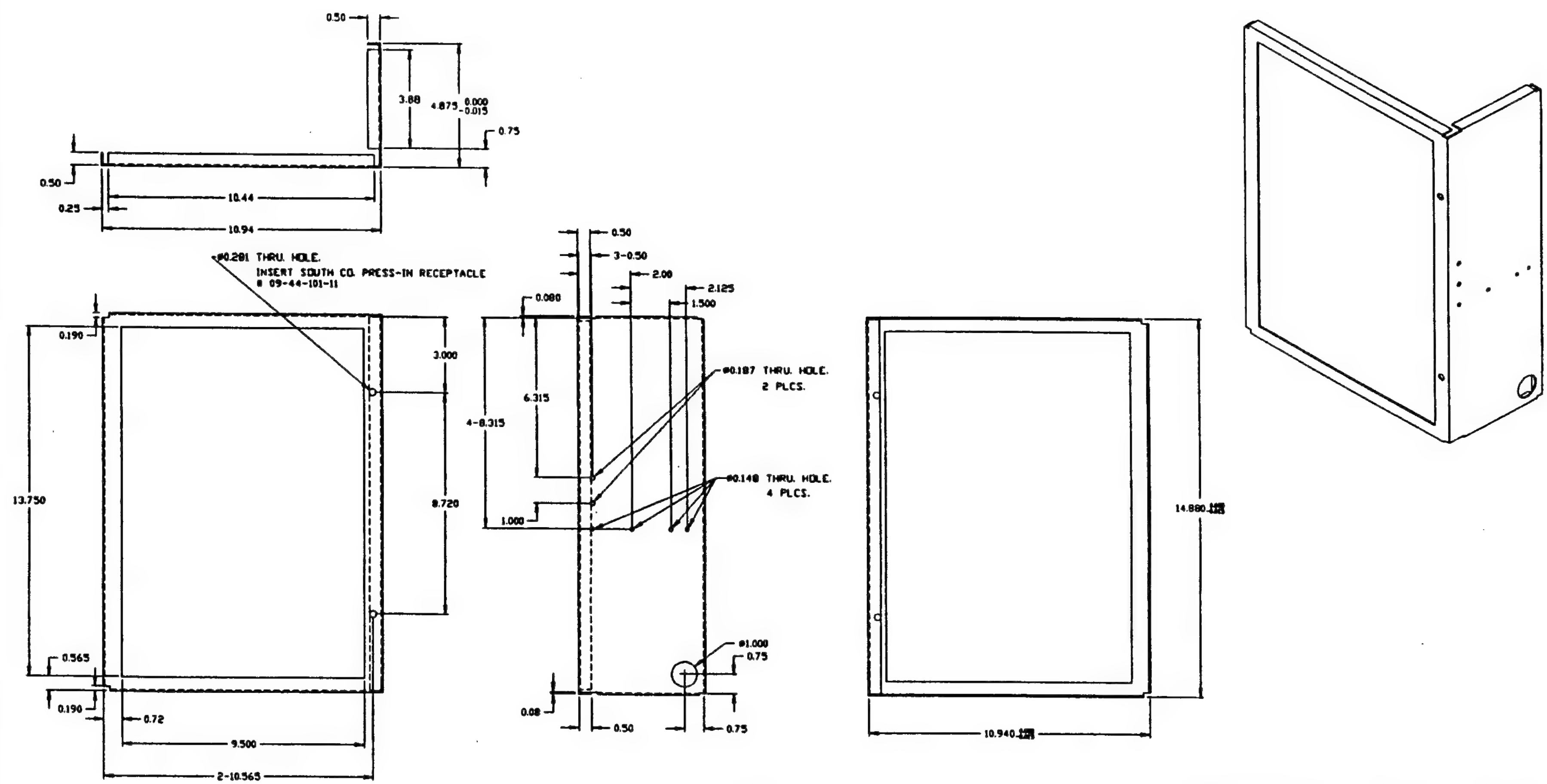
1. FINISH - ANODIZE ALL SURFACES BLACK.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.

IMPACT DESIGN	MATERIAL: ALUMINUM, 6061, T6		CUSTOMER: IRISCAN INCORPORATED
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ±1/64 DECIMALS .XX±.01 .XXX±.005 .XXXX±.001 ANGLES ±0.5°	DRAWN BY: LAM	DATE 06/01/94	TITLE: CAMERA MOUNTING BRACKET, OPTICS
	CHECKED BY:		SIZE: C DRAWING NO: 1300030 REV: 01
	ISSUED BY:		SCALE 1 = 1 SHEET: 1 OF 1
	FILE NO. 00030.DWG		


REV
01
DESCRIPTION
PROTOTYPE RELEASE
DATE
06/27/94
BY
LAH
APP'D
0.875
0.250
2-0.375
Ø0.148 DRILL THROUGH.
Ø0.266 C'BORE 0.080 DEEP.
TYP. 2 PLCS.
Ø0.257 DRILL THROUGH.
2.375
0.375
1.38
0.19
2.88
0.25
0.56
NOTE:
1. FINISH - ANODIZE ALL SURFACES BLACK.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:
MATERIAL:
ALUMINUM, 6061 T6
DRAWN BY:
LAH
CHECKED BY:
ISSUED BY:
FILE NO:
00040.DWG
CUSTOMER:
IRISCAN INCORPORATED
TITLE:
LCD MOUNTING BRACKET, OPTICS
SIZE:
C
DRAWING NO
1300040
REV:
01
SCALE:
1 = 1
SHEET:
1 OF 1


PROJECTION PA-PA
MAINTAIN FULL SHARP INSIDE CORNERS
IRISCAN INCORPORATED
CHASSIS
OPTICS


NOTE:
1. FINISH - ANODIZE ALL SURFACES BLACK.
2. BRUSH THIS SURFACE PRIOR TO ANODIZING.
3. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
IRISCAN INCORPORATED
COVER PLATE, OPTICS
1300060
SECTION SA-SA
⌀0.250 DRILL THROUGH. INSTALL PEM STUD #FHS-0420-12-NONE PROTRUDE N.S.
⌀0.070 DRILL 0.375 DEEP. TAP #2-56. 0.25 MIN. THR.
SEE NOTE #2
S.F. 0.125
SA
SA
REV
DESCRIPTION
DATE
BY
APP'D



NOTE:

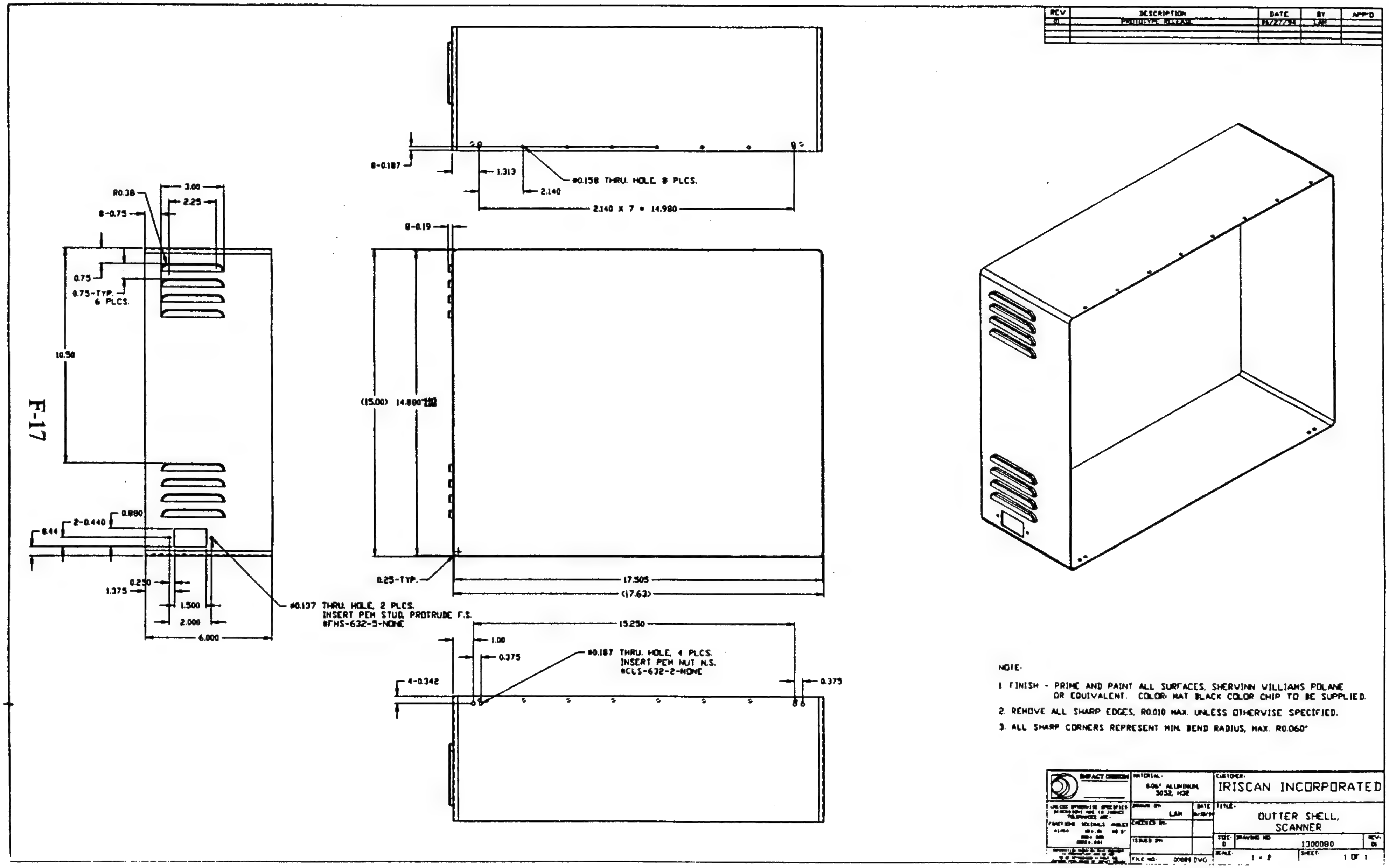
1. FINISH - PRIME AND PAINT ALL SURFACES. SHERWINN WILLIAMS POLANE OR EQUIVALENT. COLOR: MAT BLACK COLOR CHIP TO BE SUPPLIED.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
3. ALL SHARP CORNERS REPRESENT MIN. BEND RADIUS, MAX. R0.060"

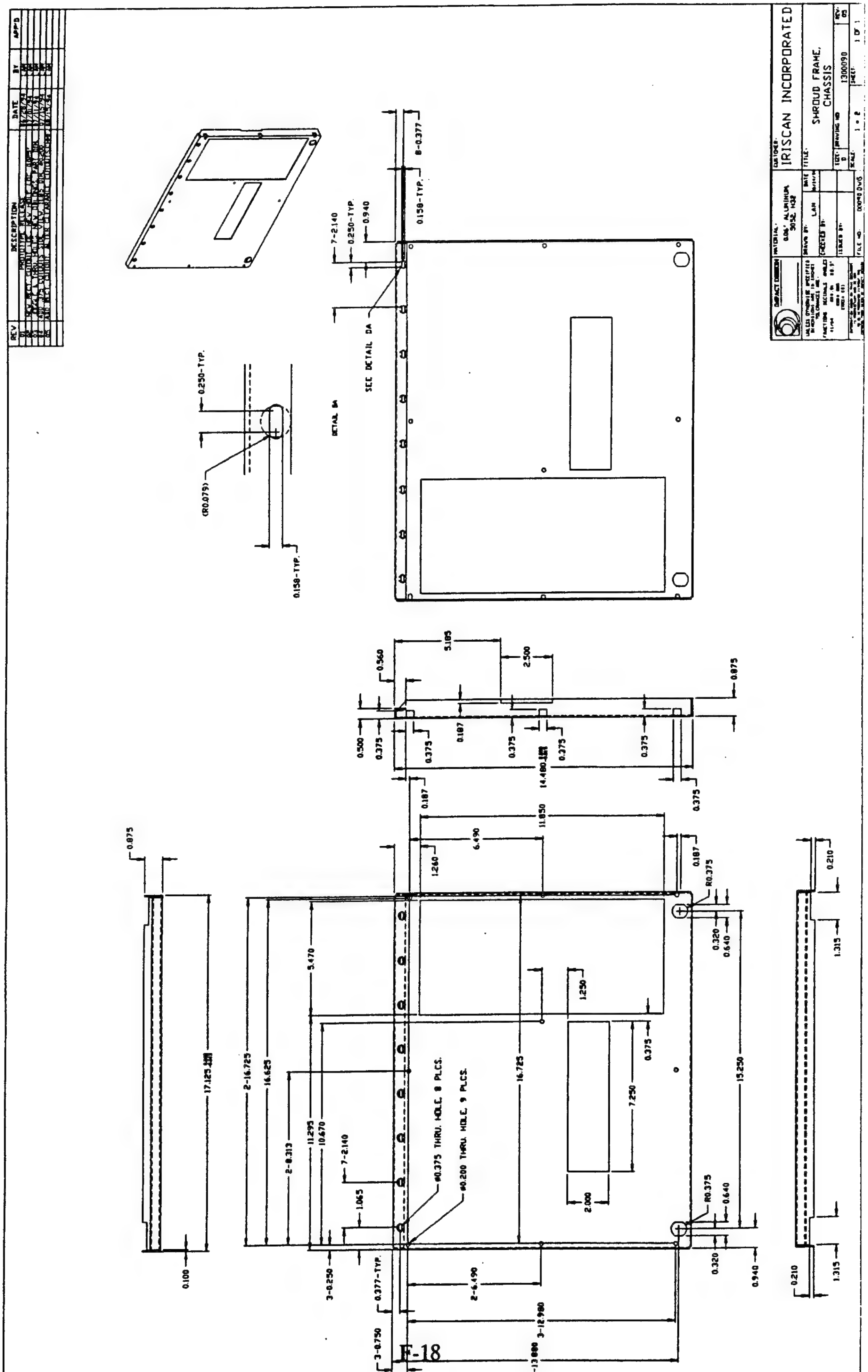
IMPACT DESIGN — MATERIAL: 0.06" ALUMINUM 5052, H32 — DRAWN BY: LAM

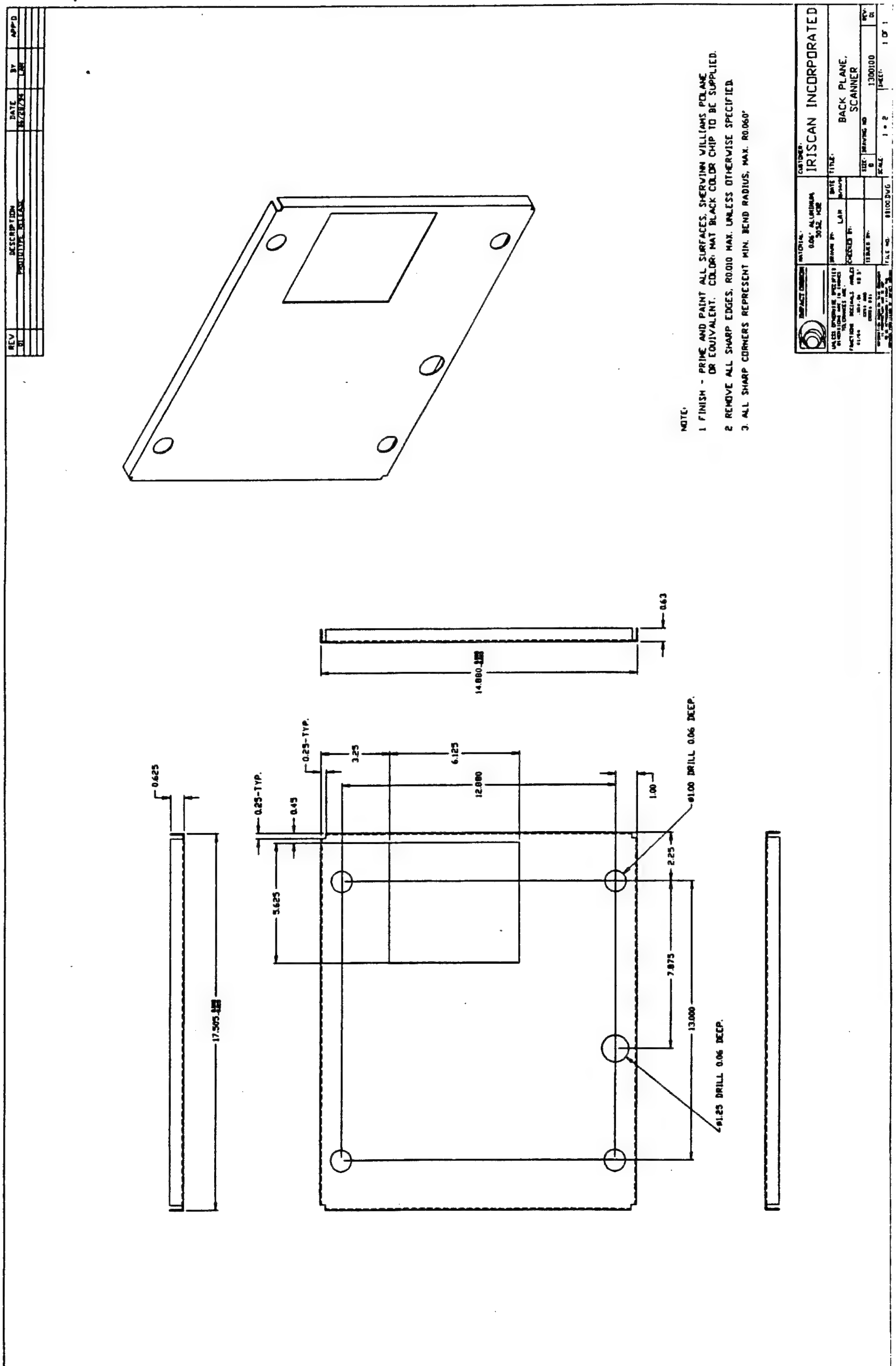
CUSTOMER: IRISCAN INCORPORATED

TITLE: MID-PLANE, SCANNER

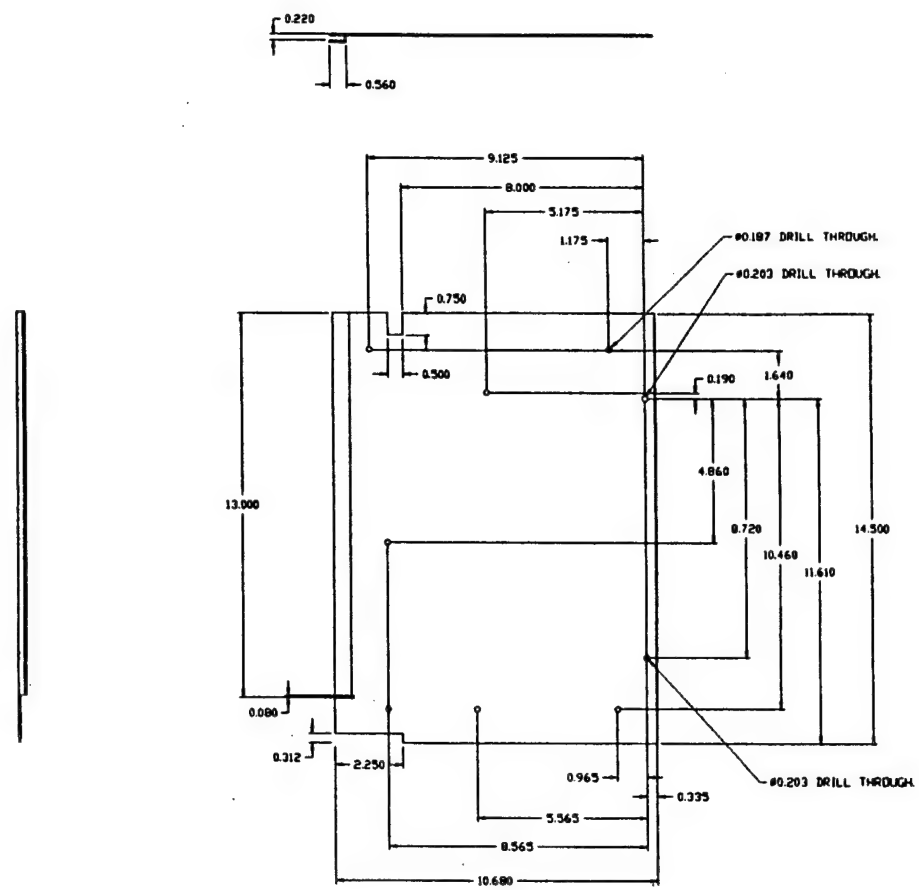
SIZE: D — DRAWING NO: 1300070 — SCALE: 1 = 2 — SHEET: 1 OF 1 — FILE NO: 00070.DWG

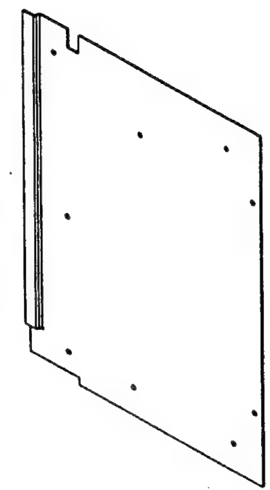

REV | DESCRIPTION | DATE | BY | APP'D
01 | PROTOTYPE RELEASE | 11/27/94 | LAM
R0.38
3.00
2.25
8-0.75
0.75
0.75-TYP. 6 PLCS.
10.50
2-0.440
0.880
8.44
0.250
1.375
1.500
2.000
6.000
ø0.137 THRU. HOLE, 2 PLCS. INSERT PEM STUD, PROTRUDE F.S. #FHS-632-5-NONE
8-0.187
1.313
2.140
ø0.158 THRU. HOLE, 8 PLCS.
2.140 X 7 = 14.980
8-0.19
(15.00)
14.880
0.25-TYP.
17.505
(17.63)
15.250
1.00
0.375
4-0.342
ø0.187 THRU. HOLE, 4 PLCS. INSERT PEM NUT N.S. #CLS-632-2-NONE
0.375
NOTE:
1 FINISH - PRIME AND PAINT ALL SURFACES, SHERWINN WILLIAMS POLANE OR EQUIVALENT. COLOR: MAT BLACK COLOR CHIP TO BE SUPPLIED.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
3. ALL SHARP CORNERS REPRESENT MIN. BEND RADIUS, MAX. R0.060"
IMPACT DESIGN
MATERIAL: 0.06" ALUMINUM, 5052, H32
DRAWN BY: LAM
CUSTOMER: IRISCAN INCORPORATED
TITLE: OUTTER SHELL, SCANNER
SIZE: D
DRAWING NO 1300080
REV: 01
SCALE: 1 = 2
SHEET: 1 OF 1
FILE NO: 00080.DWG


IRISCAN INCORPORATED
SHROUD FRAME, CHASSIS
1300090


REV
DESCRIPTION
DATE
BY
APP'D
01
PROTOTYPE RELEASE
NOTE:
1 FINISH - PRIME AND PAINT ALL SURFACES, SHERWIN WILLIAMS POLANE OR EQUIVALENT. COLOR: MAT BLACK COLOR CHIP TO BE SUPPLIED.
2 REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
3. ALL SHARP CORNERS REPRESENT MIN. BEND RADIUS, MAX. R0.060"
0.625
0.25-TYP.
0.45
5.625
0.25-TYP.
3.25
6.125
12.880
1.00
ø1.00 DRILL 0.06 DEEP.
2.25
7.875
13.000
ø1.25 DRILL 0.06 DEEP.
17.505
14.880
0.63
IRISCAN INCORPORATED
BACK PLANE, SCANNER
1300100
LAR

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	[illegible]	LAH	
02	ADD 0.75 X 0.50 CUTOUT FOR [illegible] CLEARANCE	[illegible]	LAH	



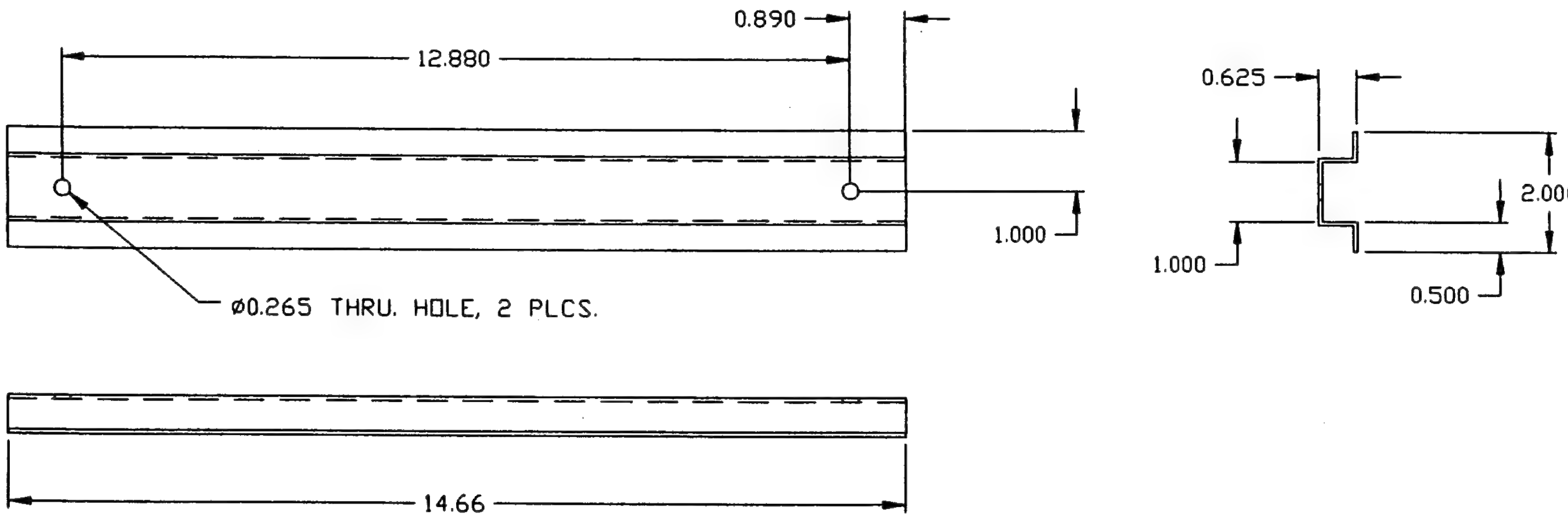


NOTE:

1. FINISH - PRIME AND PAINT ALL SURFACES, SHERWINN WILLIAMS POLANE OR EQUIVALENT. COLOR: MAT BLACK COLOR CHIP TO BE SUPPLIED.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
3. ALL SHARP CORNERS REPRESENT MIN. BEND RADIUS, MAX. R0.060"

IMPACT DESIGN	MATERIAL: 0.06" ALUMINUM 5052, H32	CUSTOMER: IRISCAN INCORPORATED
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	DRAWN BY: LAH	TITLE: CPU DOOR, SCANNER
	CHECKED BY:	SIZE: D · DRAWING NO: 1300110 · REV: 02
	ISSUED BY:	SCALE: 1 = 2 · SHEET: 1 OF 1
	FILE NO: 00110	

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	06/27/94	LAM	



NOTE:

1. FINISH - PRIME AND PAINT ALL SURFACES, SHERWINN WILLIAMS POLANE OR EQUIVALENT. COLOR: MAT BLACK COLOR CHIP TO BE SUPPLIED.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
3. ALL SHARP CORNERS REPRESENT MIN. BEND RADIUS, MAX. R0.060"

IMPACT DESIGN
INDUSTRIAL DESIGN CONSULTANTS
CLINTON NJ 908/730-9669

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

FRACTIONS	DECIMALS	ANGLES
±1/64	.XX±.01	±0.5°
	.XXX±.005	
	.XXXX±.001	

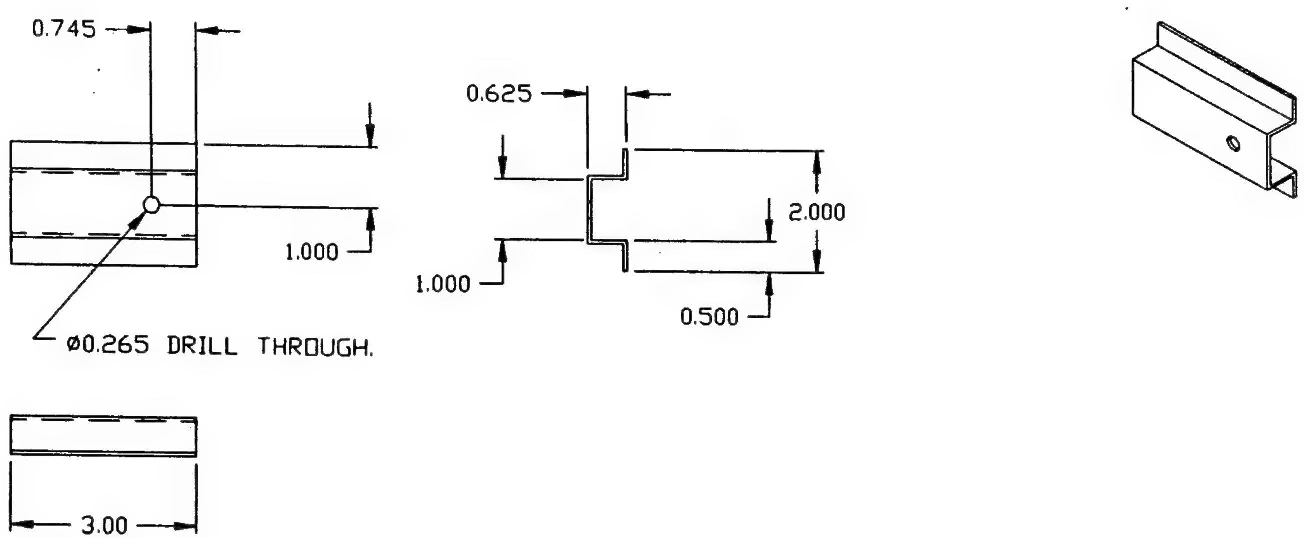
MATERIAL: 0.06" ALUMINUM, 5052, H32		
DRAWN BY: LAM	DATE 6/22/94	
CHECKED BY:		
ISSUED BY:		
FILE NO.: 00120.DWG		

CUSTOMER: IRISCAN INCORPORATED

TITLE: LARGE HANGER BRACKET, BACK PLANE

SIZE:	DRAWING NO:	REV:
B	1300120	01
SCALE: 1 = 2	SHEET: 1 OF 1	

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	06/27/94	LAM	



NOTE:

1. FINISH - PRIME AND PAINT ALL SURFACES, SHERWINN WILLIAMS POLANE OR EQUIVALENT. COLOR: MAT BLACK COLOR CHIP TO BE SUPPLIED.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
3. ALL SHARP CORNERS REPRESENT MIN. BEND RADIUS, MAX. R0.060"

IMPACT DESIGN

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:
FRACTIONS ±1/64 DECIMALS .XX±.01 .XXX±.005 .XXXX±.001 ANGLES ±0.5°

MATERIAL: 0.06" ALUMINUM, 5052, H32

DRAWN BY: LAM DATE: 06/22/94

CHECKED BY:

ISSUED BY:

FILE NO: 00120.DWG

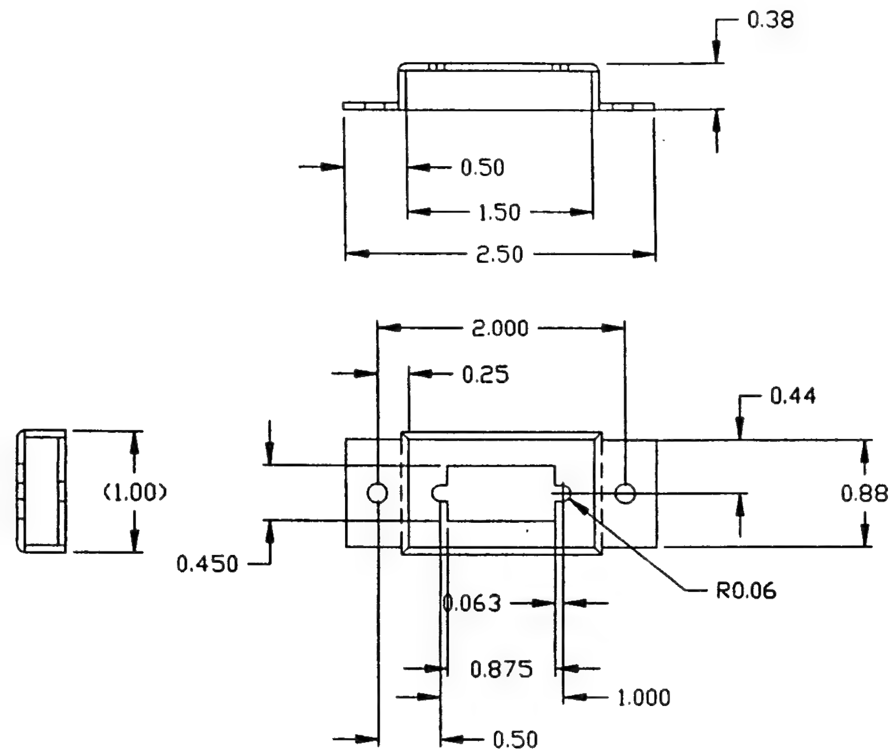
CUSTOMER: IRISCAN INCORPORATED

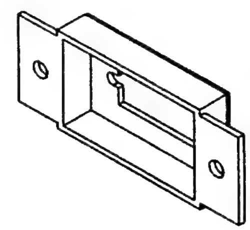
TITLE: SMALL HANGER BRACKET, BACK PLANE

SIZE: B | DRAWING NO: 1300130 | REV: 01

SCALE: 1 = 2 | SHEET: 1 OF 1

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	06/27/94	LAM	





NOTE:

1. FINISH - PRIME AND PAINT ALL SURFACES, SHERWINN WILLIAMS POLANE OR EQUIVALENT. COLOR: MAT BLACK COLOR CHIP TO BE SUPPLIED.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
3. ALL SHARP CORNERS REPRESENT MIN. BEND RADIUS, MAX. R0.060"

IMPACT DESIGN

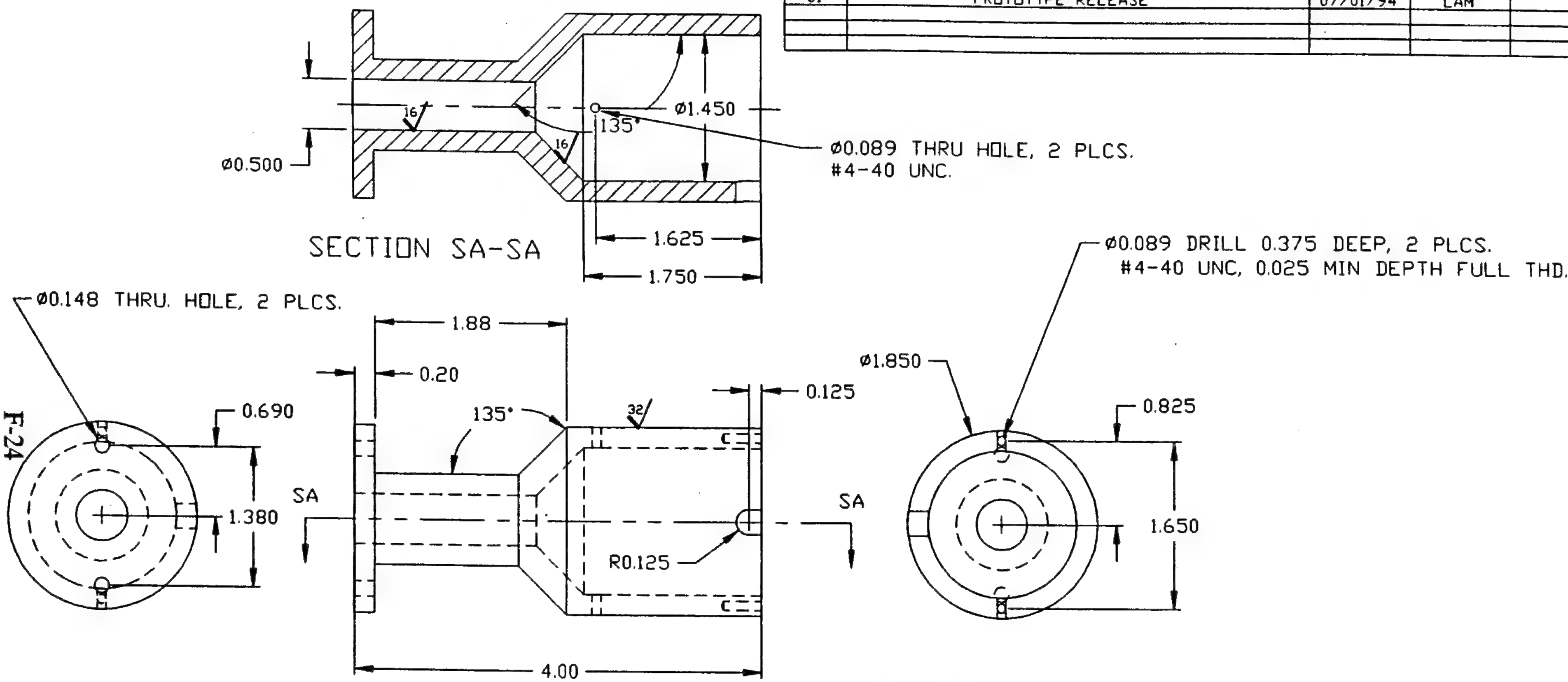
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

FRACTIONS	DECIMALS	ANGLES
±1/64	.XX±.01	±0.5°
	.XXX±.005	
	.XXXX±.001	

INFORMATION SHOWN ON THIS DOCUMENT IS PROPRIETARY AND IS NOT TO BE REPRODUCED WITHOUT THE EXPRESS PERMISSION OF IMPACT DESIGN

MATERIAL:	0.06" ALUMINUM, 5052, H32
DRAWN BY: LAM	DATE 6/22/94
CHECKED BY:	
ISSUED BY:	
FILE NO.:	00140.DWG
CUSTOMER:	IRISCAN INCORPORATED
TITLE:	I.O. BRACKET, SCANNER
SIZE: B	DRAWING NO: 1300140
REV:	01
SCALE:	1 = 1
SHEET:	1 OF 1

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	07/01/94	LAM	

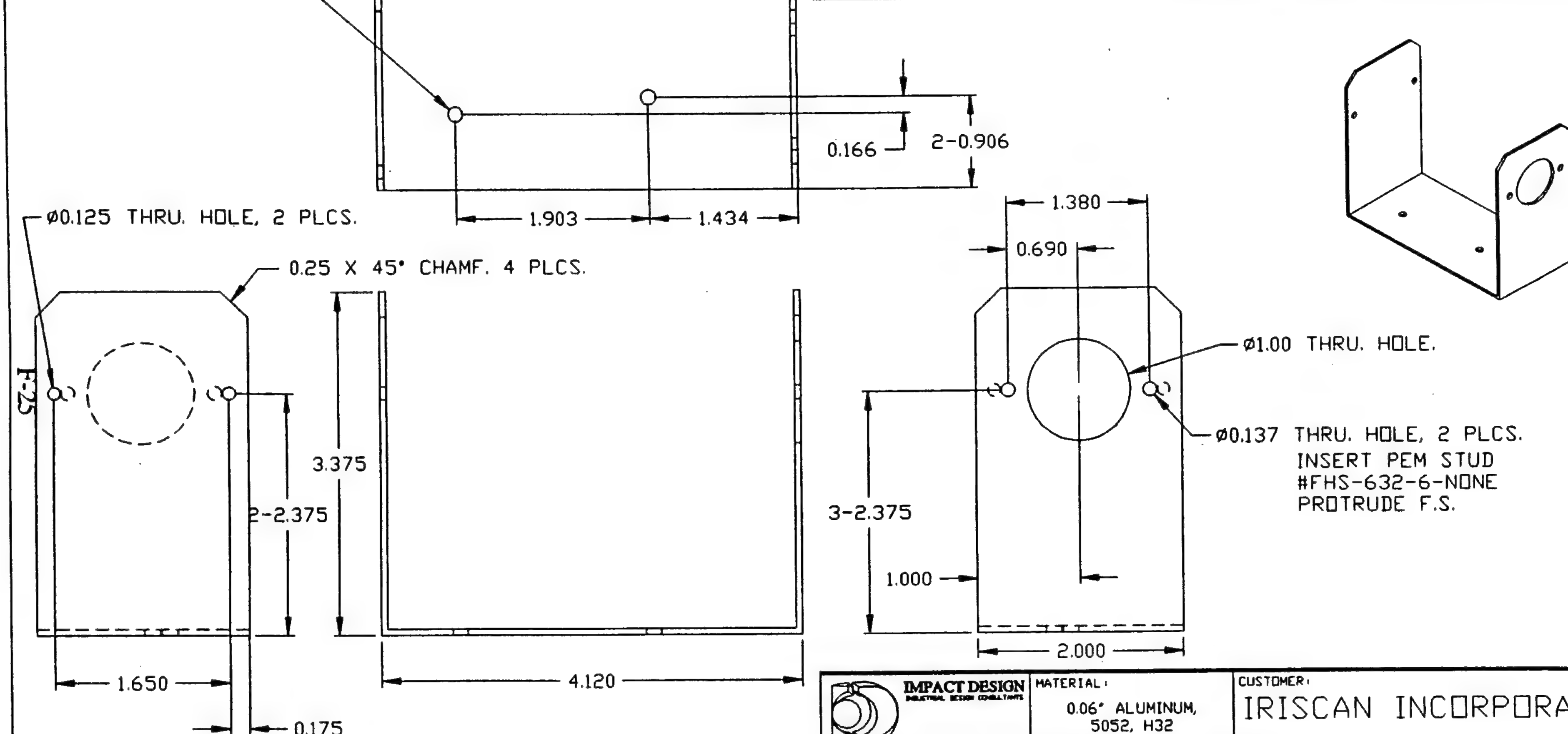


NOTE:

1. FINISH - NATURAL, POLISH INTERIOR SURFACE WHERE SPECIFIED 16/, ALL OTHER SURFACES 32/.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.

IMPACT DESIGN INDUSTRIAL DESIGN CONSULTANTS	MATERIAL: ALUMINUM, 6061, T6		CUSTOMER: IRISCAN CORPORATION
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ±1/64 DECIMALS .XX± .01 .XXX± .005 .XXXX± .001 ANGLES ±0.5°	DRAWN BY: LAM	DATE 6/29/94	TITLE: LIGHT PIPE, OPTICS
	CHECKED BY:		SIZE: B DRAWING NO: 1300150 REV: 01
INFORMATION SHOWN ON THIS DOCUMENT IS PROPRIETARY AND IS NOT TO BE REPRODUCED WITHOUT THE EXPRESS PERMISSION OF IMPACT DESIGN	ISSUED BY:		SCALE: 1 = 1 SHEET: 1 OF 1
	FILE NO.: 00150.DWG		

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	06/29/94	LAM	
02	NEW Ø0.148 HOLE LOCATION 2 PLCS.	07/12/94	LAM	



NOTE:

1. FINISH - PRIME AND PAINT ALL SURFACES, SHERWINN WILLIAMS POLANE OR EQUIVALENT. COLOR: MAT BLACK COLOR CHIP TO BE SUPPLIED.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
3. ALL SHARP CORNERS REPRESENT MIN. BEND RADIUS, MAX. R0.060"

IMPACT DESIGN
INDUSTRIAL DESIGN CONSULTANTS
CLINTON NJ 908/730-9669

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

FRACTIONS	DECIMALS	ANGLES
±1/64	.XX±.01	±0.5°
	.XXX±.005	
	.XXXX±.001	

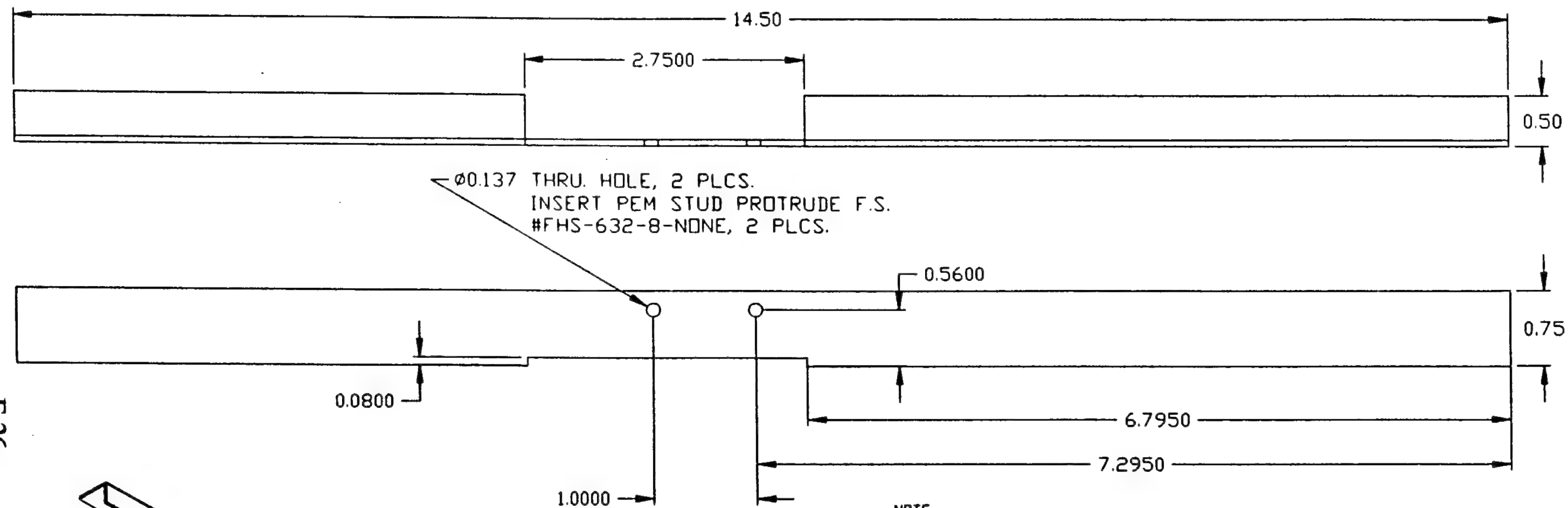
MATERIAL:	0.06" ALUMINUM, 5052, H32
DRAWN BY: LAM	DATE 6/29/94
CHECKED BY:	
ISSUED BY:	
FILE NO:	00160.DWG

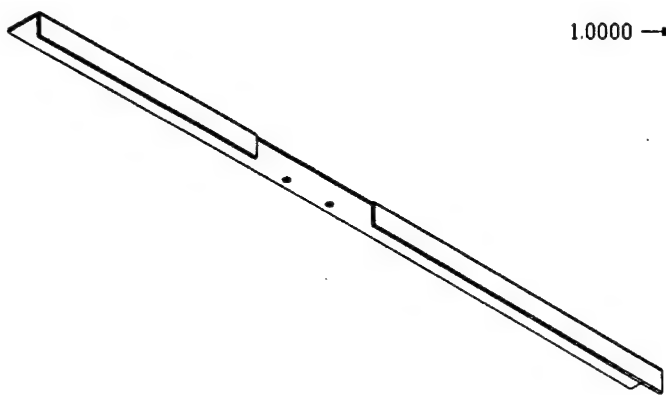
CUSTOMER: IRISCAN INCORPORATED

TITLE: BRACKET MOUNT, LIGHT PIPE

SIZE:	DRAWING NO:	REV:
B	1300160	02
SCALE: 1 = 1	SHEET: 1 OF 1	

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	07/01/94	LAM	
02	CHANGE 2.00 CUTOUT TO 2.75	07/15/94	LAM	





NOTE:

1. FINISH - PRIME AND PAINT ALL SURFACES, SHERWINN WILLIAMS POLANE OR EQUIVALENT. COLOR: MAT BLACK COLOR CHIP TO BE SUPPLIED.
2. REMOVE ALL SHARP EDGES, R0.010 MAX. UNLESS OTHERWISE SPECIFIED.
3. ALL SHARP CORNERS REPRESENT MIN. BEND RADIUS, MAX. R0.060"

IMPACT DESIGN INDUSTRIAL DESIGN CONSULTANTS

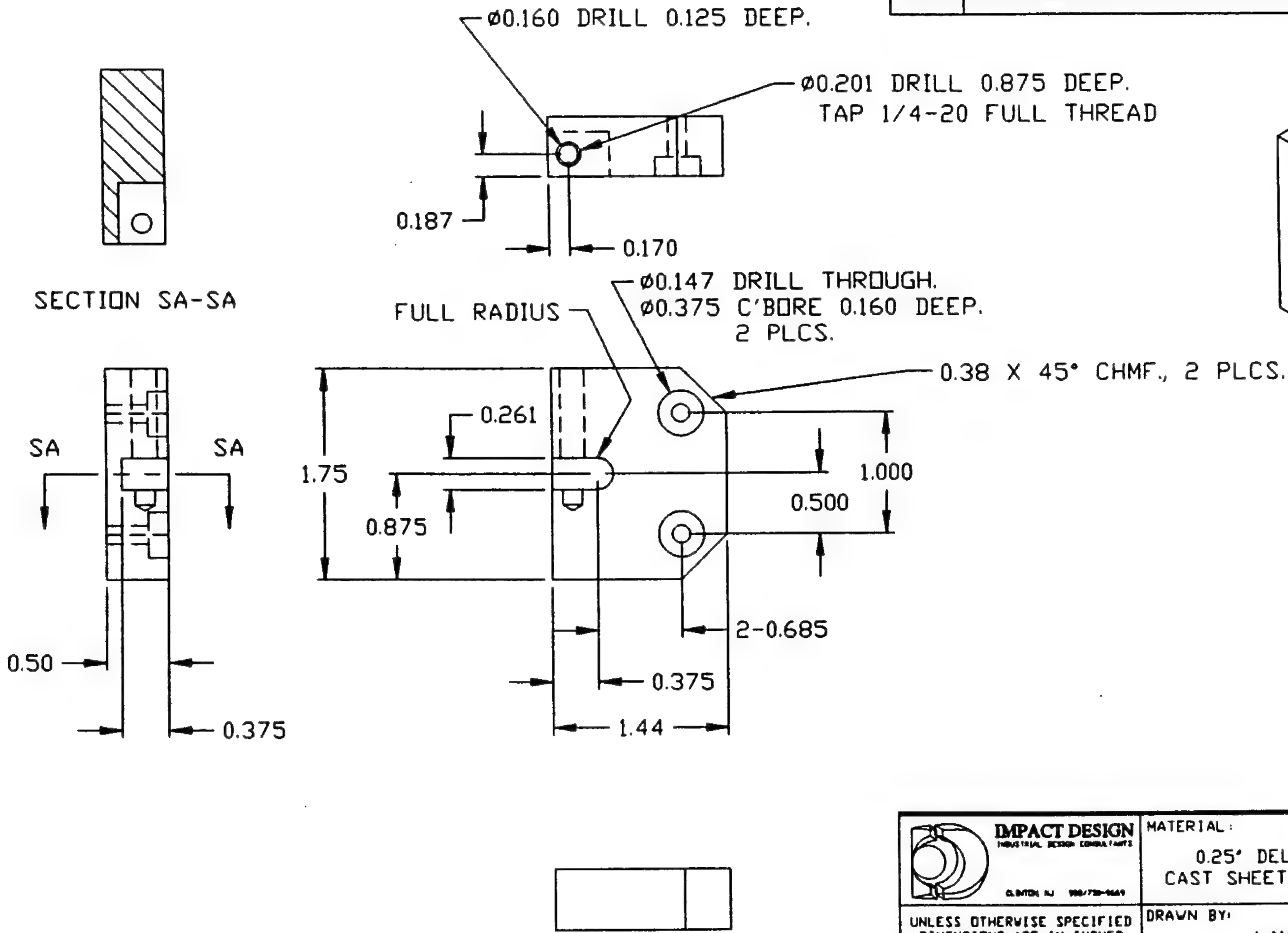
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

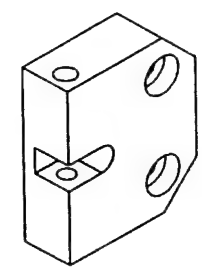
FRACTIONS	DECIMALS	ANGLES
±1/64	.XX±.01	±0.5°
	.XXX±.005	
	.XXXX±.001	

INFORMATION SHOWN ON THIS DOCUMENT IS PROPRIETARY AND IS NOT TO BE REPRODUCED WITHOUT THE EXPRESS PERMISSION OF IMPACT DESIGN

MATERIAL: 0.06" ALUMINUM, 5052, H32		CUSTOMER: IRISCAN INCORPORATED
DRAWN BY: LAM	DATE 07/01/94	TITLE: ANGLE BRACKET, CHASSIS
CHECKED BY:		SIZE: B · DRAWING NO: 1300170 · REV: 02
ISSUED BY:		
FILE NO: 00170.DWG		SCALE: 1 = 1 · SHEET: 1 OF 1

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	07/01/94	LAM	
02	INVERT Ø0.160 AND Ø0.201 DRILL DETAILS.	07/15/94	LAM	



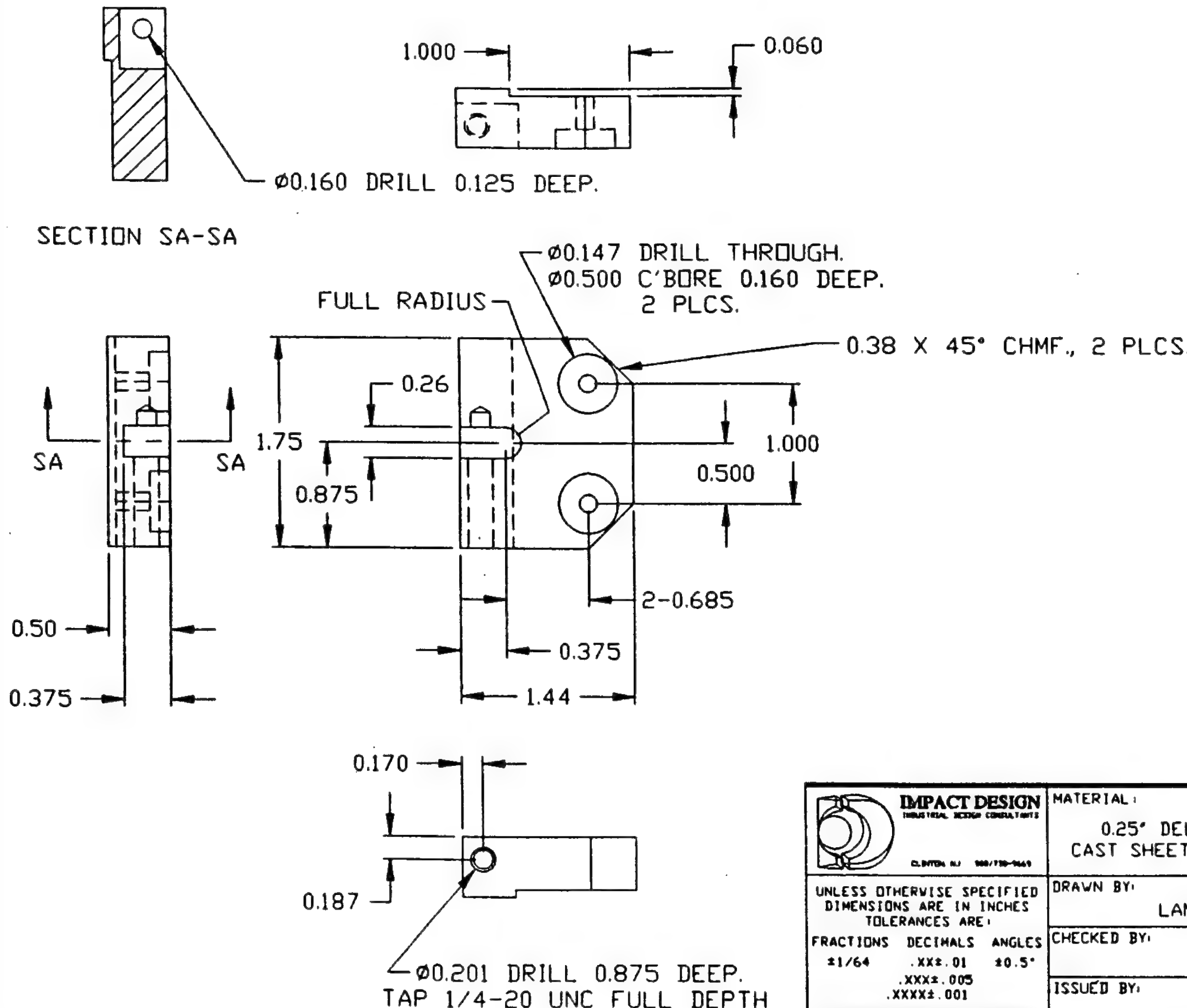


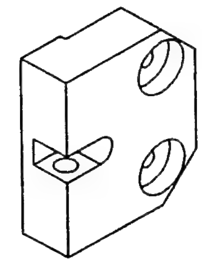
NOTES:

1. MACHINED DELRIN, COLOR: BLACK.
2. REMOVE ALL BURRS.

IMPACT DESIGN INDUSTRIAL DESIGN CONSULTANTS	MATERIAL: 0.25" DELRIN, CAST SHEET STOCK		CUSTOMER: IRISCAN INCORPORATED	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ±1/64 DECIMALS .XX±.01 .XXX±.005 .XXXX±.001 ANGLES ±0.5°	DRAWN BY: LAM	DATE 07/01/94	TITLE: LEFT MOUNTING BLOCK, OPTICS	
	CHECKED BY:		SIZE: B	DRAWING NO: 1300180 REV: 02
	ISSUED BY:		SCALE: 1 = 1	SHEET: 1 OF 1
INFORMATION SHOWN ON THIS DOCUMENT IS PROPRIETARY AND IS NOT TO BE REPRODUCED WITHOUT THE EXPRESS PERMISSION OF IMPACT DESIGN	FILE NO: 00190.DWG			

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	07/01/94	LAM	
02	CHANGE 0.375 C'BORE TO 0.500 C'BORE	08/15/94	LAM	





NOTES:

1. MACHINED DELRIN, COLOR: BLACK.
2. REMOVE ALL BURRS.

IMPACT DESIGN
INDUSTRIAL DESIGN CONSULTANTS
CLINTON NJ

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

FRACTIONS	DECIMALS	ANGLES
±1/64	.XX±.01	±0.5°
	.XXX±.005	
	.XXXX±.001	

INFORMATION SHOWN ON THIS DOCUMENT IS PROPRIETARY AND IS NOT TO BE REPRODUCED WITHOUT THE EXPRESS PERMISSION OF IMPACT DESIGN

MATERIAL: 0.25" DELRIN, CAST SHEET STOCK

DRAWN BY: LAM — DATE 07/01/94

CHECKED BY:

ISSUED BY:

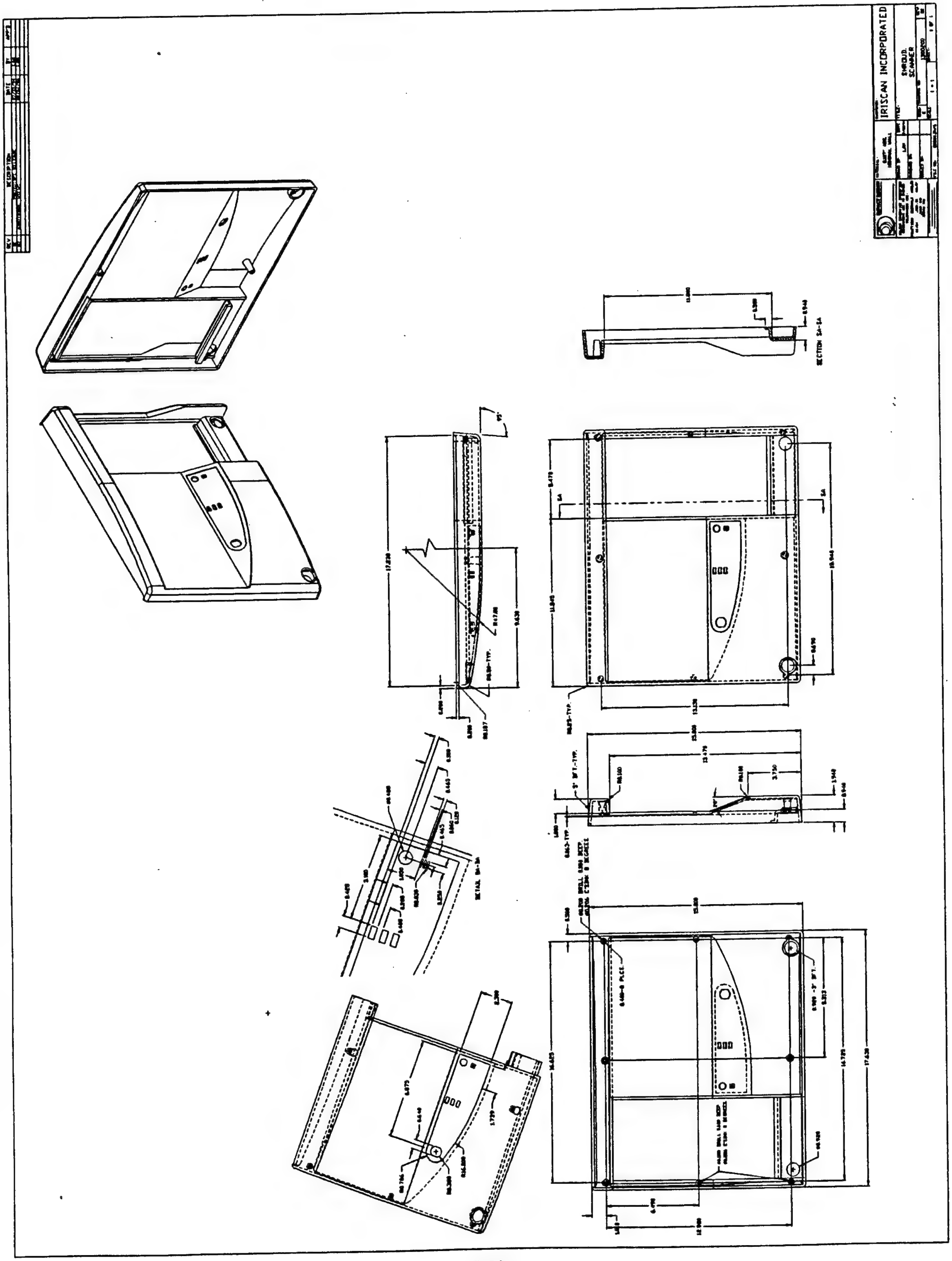
FILE NO: 00190.DWG

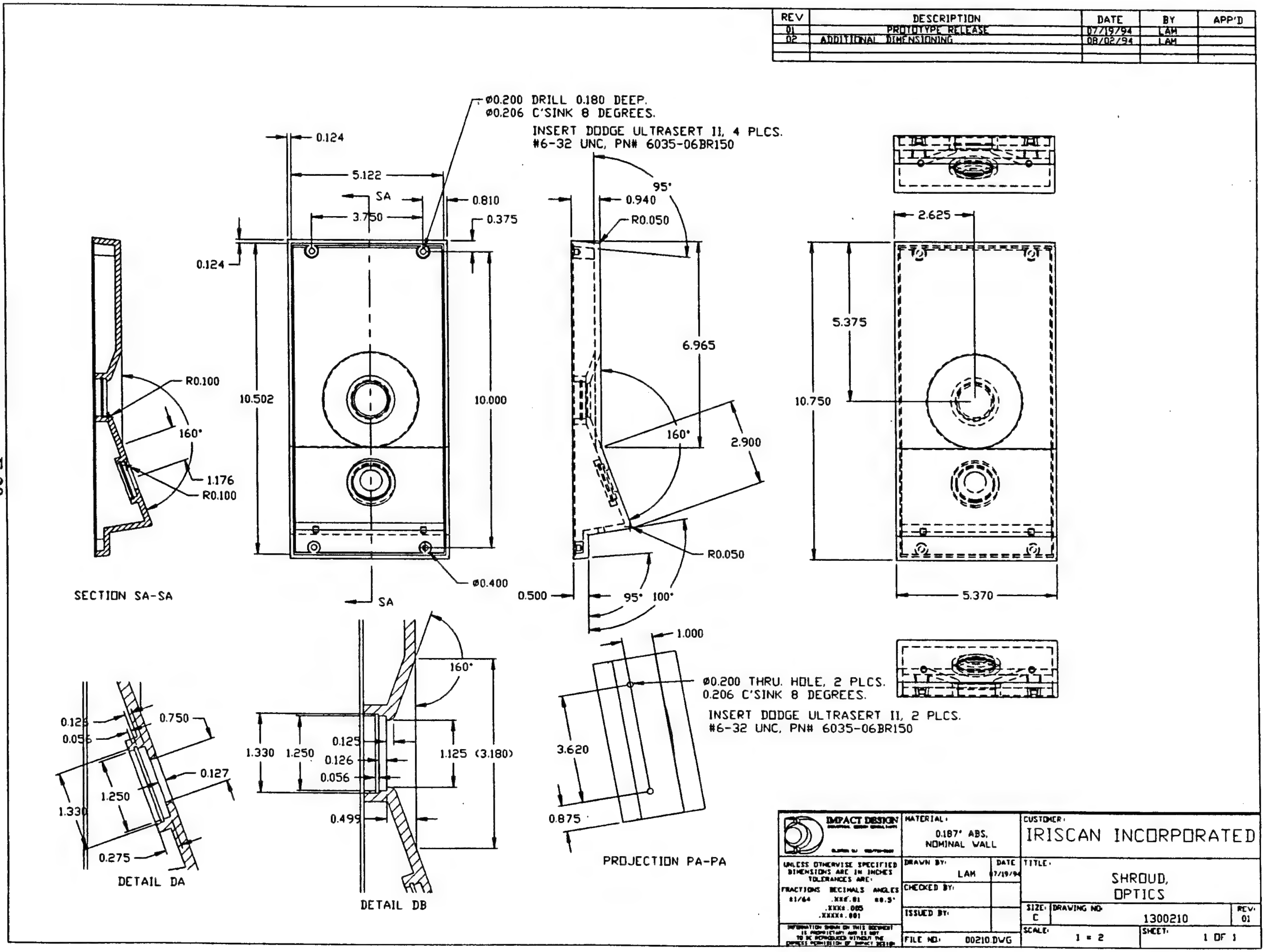
CUSTOMER: IRISCAN INCORPORATED

TITLE: RIGHT MOUNTING BLOCK, OPTICS

SIZE: B — DRAWING NO: 1300190 — REV: 02

SCALE: 1 = 1 — SHEET: 1 OF 1


IRISCAN INCORPORATED
SHROUD, SCANNER



REV | DESCRIPTION | DATE | BY | APP'D
01 | PROTOTYPE RELEASE | 07/19/94 | LAM
02 | ADDITIONAL DIMENSIONING | 08/02/94 | LAM
ø0.200 DRILL 0.180 DEEP.
ø0.206 C'SINK 8 DEGREES.
INSERT DODGE ULTRASERT II, 4 PLCS.
#6-32 UNC, PN# 6035-06BR150
0.124
5.122
SA
3.750
0.810
0.375
10.502
10.000
ø0.400
R0.100
160°
1.176
R0.100
SECTION SA-SA
95°
0.940
R0.050
6.965
2.900
R0.050
0.500
95°
100°
2.625
5.375
10.750
5.370
1.000
ø0.200 THRU. HOLE, 2 PLCS.
0.206 C'SINK 8 DEGREES.
INSERT DODGE ULTRASERT II, 2 PLCS.
#6-32 UNC, PN# 6035-06BR150
3.620
0.875
PROJECTION PA-PA
0.125
0.056
0.750
0.127
1.250
1.330
0.275
DETAIL DA
1.330
1.250
0.125
0.126
0.056
0.499
1.125
(3.180)
DETAIL DB
IMPACT DESIGN
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:
FRACTIONS ±1/64 DECIMALS .XXX ±.01 .XXXX ±.005 .XXXXX ±.001 ANGLES ±0.5°
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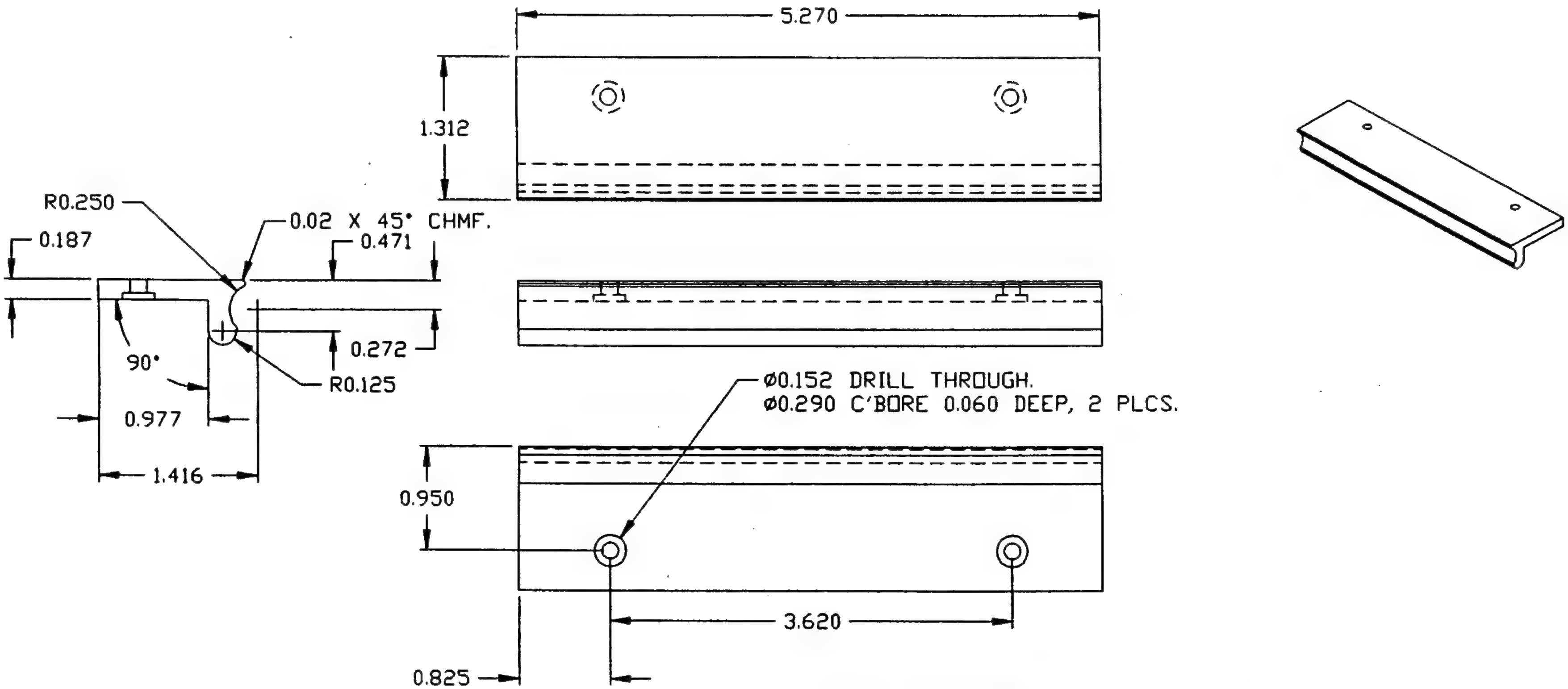
CHECKED BY:
ISSUED BY:
FILE NO: 00210.DWG
CUSTOMER: IRISCAN INCORPORATED
TITLE: SHROUD, OPTICS
SIZE: C
DRAWING NO: 1300210
REV: 01
SCALE: 1 = 2
SHEET: 1 OF 1

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	07/24/94	LAM	



NOTE:

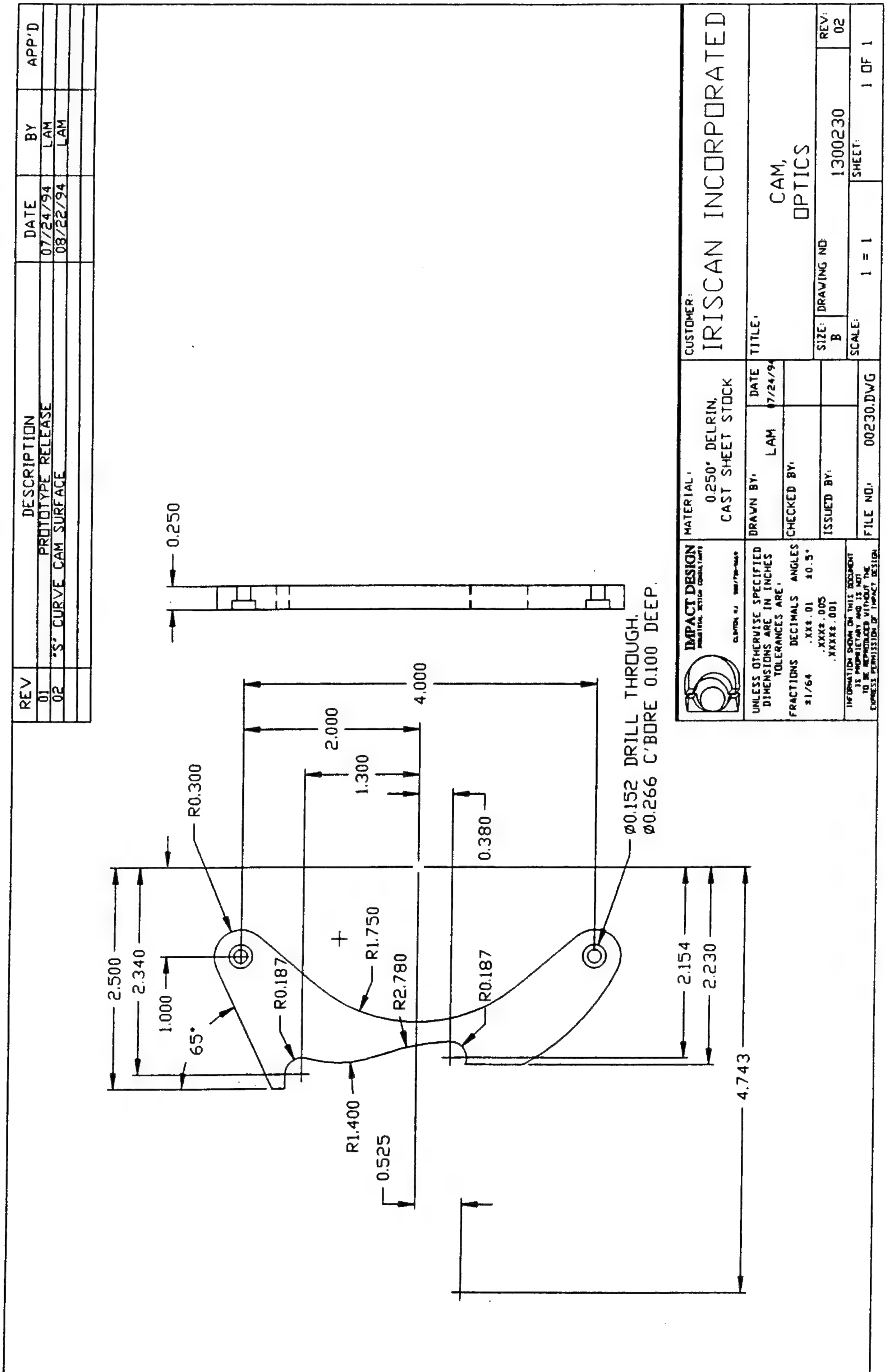
1. FINISH - ANODIZE ALL SURFACES BLACK.
2. SANDBLAST SURFACES PRIOR TO ANODIZING.
3. REMOVE ALL SHARP EDGES, R0.010 MAX.

IMPACT DESIGN
INDUSTRIAL DESIGN CONSULTANTS
CLINTON NJ

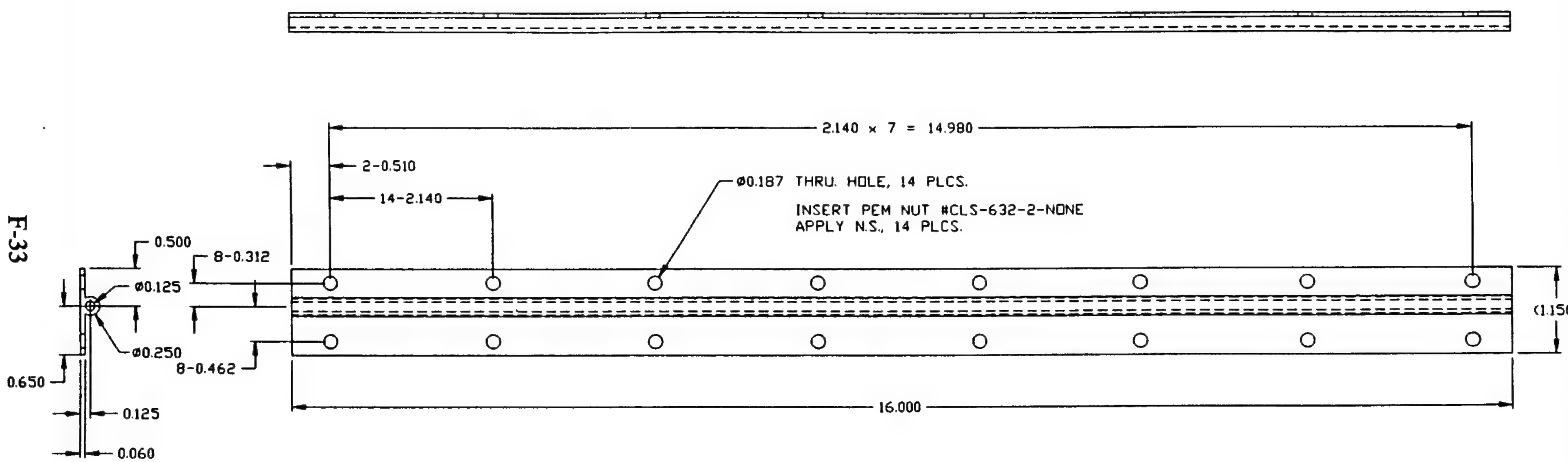
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

FRACTIONS	DECIMALS	ANGLES
±1/64	.XX±.01	±0.5°
	.XXX±.005	
	.XXXX±.001	

MATERIAL: ALUMINUM, 6061, T6		CUSTOMER: IRISCAN INCORPORATED	
DRAWN BY: LAM	DATE 07/24/94	TITLE: HANDLE, OPTICS	
CHECKED BY:		SIZE: B	DRAWING NO: 1300220 — REV: 01
ISSUED BY:			
FILE NO: 00220		SCALE: 1 = 1	SHEET: 1 OF 1


REV | DESCRIPTION | DATE | BY | APP'D
01 | PROTOTYPE RELEASE | 07/24/94 | LAM
02 | "S" CURVE CAM SURFACE | 08/22/94 | LAM
0.250
4.000
2.000
1.300
0.380
R0.300
Ø0.152 DRILL THROUGH.
Ø0.266 C'BORE 0.100 DEEP.
R1.750
R2.780
R0.187
R0.187
R1.400
2.500
2.340
1.000
65°
0.525
2.154
2.230
4.743
IMPACT DESIGN
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:
FRACTIONS ±1/64 DECIMALS .XX±.01 .XXX±.005 .XXXX±.001 ANGLES ±0.5°
MATERIAL: 0.250" DELRIN, CAST SHEET STOCK
DRAWN BY: LAM
DATE 07/24/94
CHECKED BY:
ISSUED BY:
FILE NO: 00230.DWG
CUSTOMER: IRISCAN INCORPORATED
TITLE: CAM, OPTICS
SIZE: B
DRAWING NO: 1300230
REV: 02
SCALE: 1 = 1
SHEET: 1 OF 1

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	08/01/94	LAM	

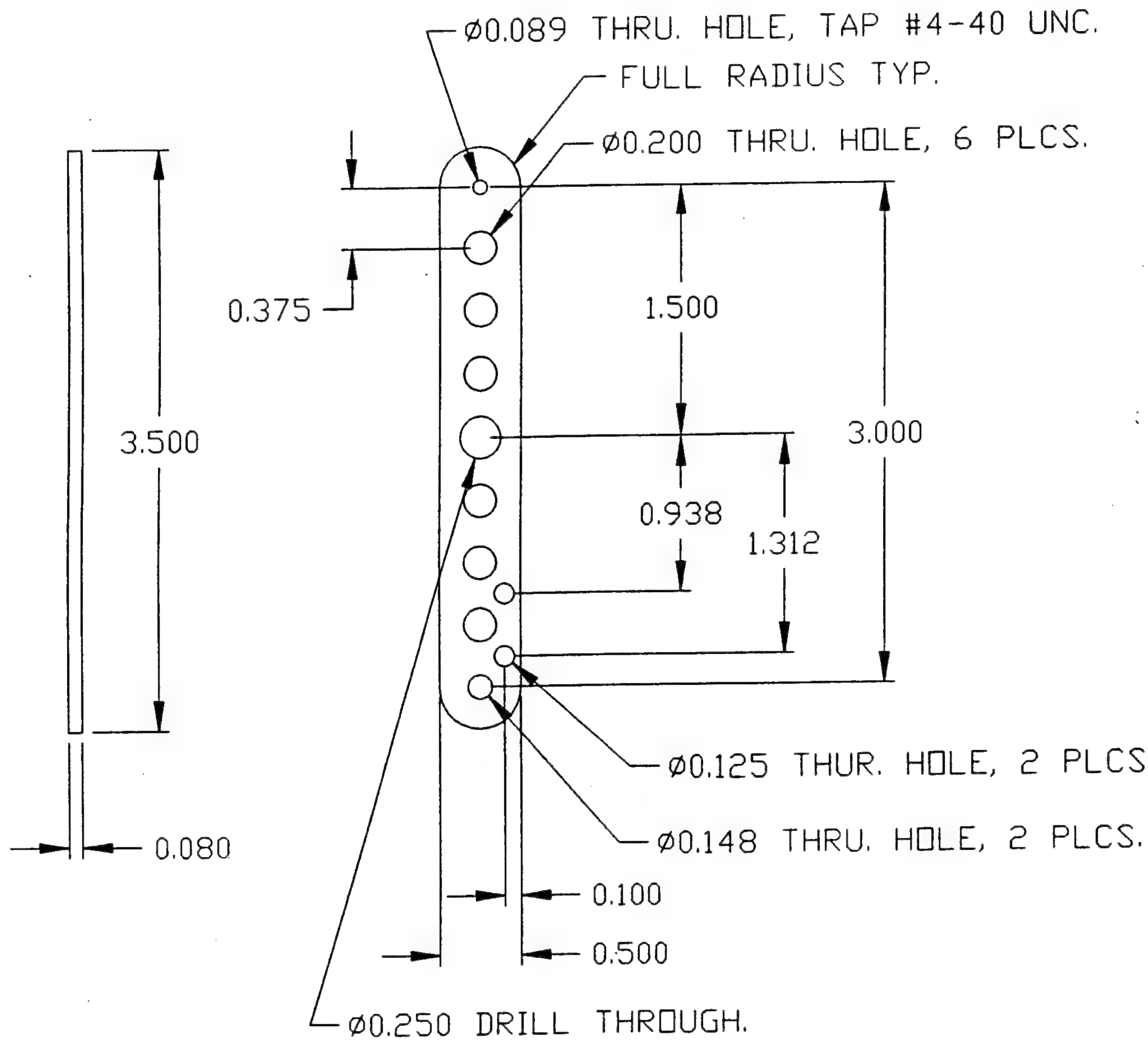


NOTE:

1. APPLY ALTERATIONS TO PART NO. 1606A41, SLIP JOINT CONT. HINGE.
   SUPPLIER: MCMASTER-CARR P.O. BOX #440
   NEW BRUNSWICK, NJ 08903-0440
   (908) 329-3200

IMPACT DESIGN	MATERIAL: 0.060" CRCO STEEL, SEE NOTE #1	CUSTOMER: IRISCAN INCORPORATED
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ±1/64 DECIMALS .XX± .01 .XXX± .005 .XXXX± .001 ANGLES ±0.5°	DRAWN BY: LAM DATE 08/01/94	TITLE: SHROUD HINGE, SCANNER
	CHECKED BY:	SIZE: C DRAWING NO: 1300250 REV: 01
	ISSUED BY:	
INFORMATION SHOWN ON THIS DOCUMENT IS PROPRIETARY AND IS NOT TO BE REPRODUCED WITHOUT THE EXPRESS PERMISSION OF IMPACT DESIGN	FILE NO: 00250.DWG	SCALE: 1 = 1 SHEET: 1 OF 1

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	08/01/94	LAM	
02	CHANGE PIVOT HOLE DIA. 0.250	08/15/94	LAM	



IMPACT DESIGN
INDUSTRIAL DESIGN CONSULTANTS
CLINTON, NJ 908/730-9669

MATERIAL: 0.080" CRCQ STEEL

CUSTOMER: IRISCAN INCORPORATED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

FRACTIONS	DECIMALS	ANGLES
±1/64	.XX±.01	±0.5°
	.XXX±.005	
	.XXXX±.001	

DRAWN BY: LAM — DATE 08/01/94

CHECKED BY:

ISSUED BY:

TITLE: FOLLOWER ARM

SIZE: A — DRAWING NO: 1300260.DWG — REV: 02

SCALE: 1 = 1 — SHEET: 1 OF 1

FILE NO.: 00260.DWG

F-34

REV	DESCRIPTION	DATE	BY	APP'D
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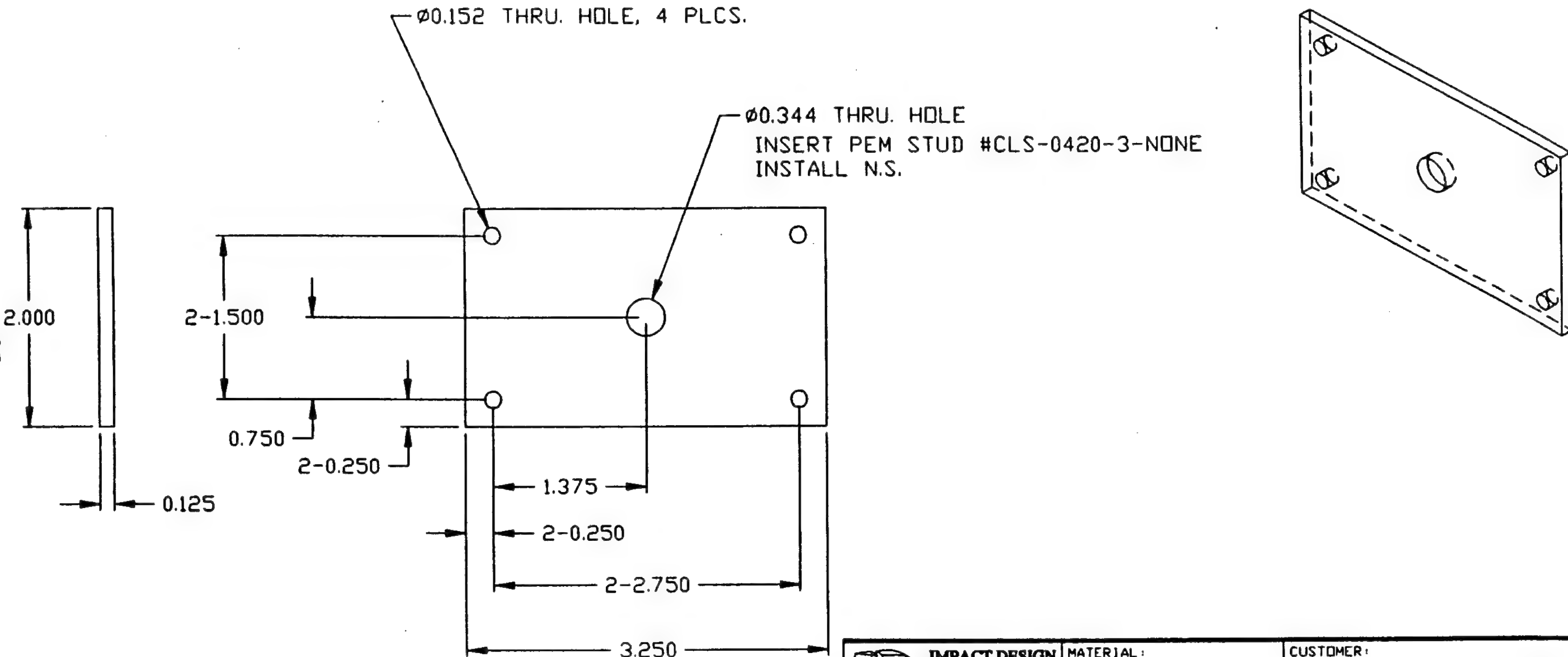

IMPACT DESIGN	MATERIAL: 0.125" ALUMINUM, 6061, T6	CUSTOMER: IRISCAN INCORPORATED
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ±1/64; DECIMALS .XX±.01 .XXX±.005 .XXXX±.001; ANGLES ±0.5°	DRAWN BY: LAM — DATE 08/01/94	TITLE: TRIPOD MOUNT PLATE, OPTICS
	CHECKED BY:	SIZE: B — DRAWING NO: 1300270 — REV: 01
INFORMATION SHOWN ON THIS DOCUMENT IS PROPRIETARY AND IS NOT TO BE REPRODUCED WITHOUT THE EXPRESS PERMISSION OF IMPACT DESIGN	ISSUED BY:	SCALE: 1 = 1 — SHEET: 1 OF 1
	FILE NO: 00270.DWG	

REV	DESCRIPTION	DATE	BY	APP'D
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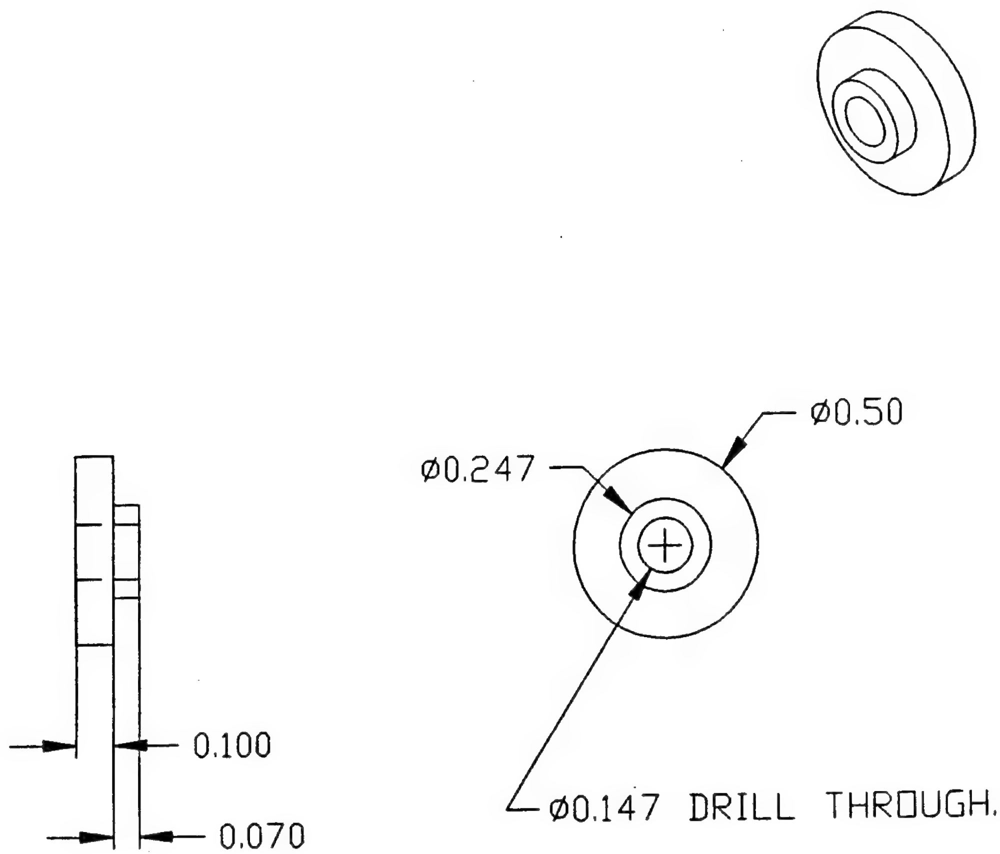


IMPACT DESIGN
INDUSTRIAL DESIGN CONSULTANTS
CLINTON, NJ 908/730-9669

MATERIAL: DELRIN

CUSTOMER: IRISCAN INCORPORATED

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ARE:

FRACTIONS	DECIMALS	ANGLES
±1/64	.XX±.01	±0.5°
	.XXX±.005	
	.XXXX±.001	

DRAWN BY: LAM — DATE: 08/15/94

CHECKED BY:

ISSUED BY:

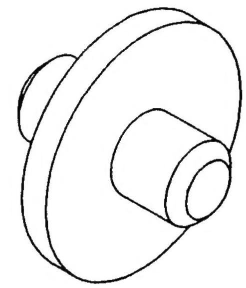
TITLE: FOLLOWER BEARING, CHASSIS

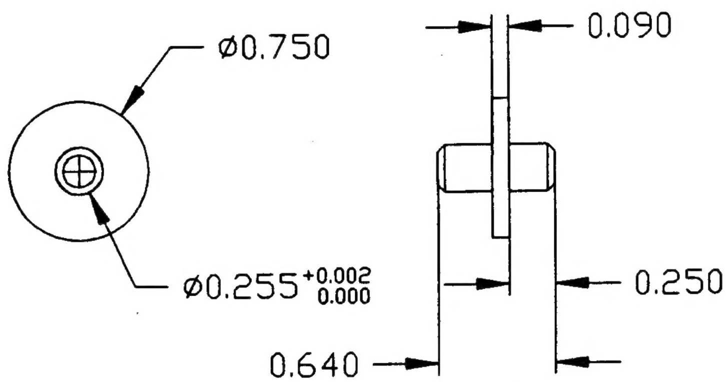
SIZE: A — DRAWING NO: 1300280 — REV: 01

SCALE: 2 = 1 — SHEET: 1 OF 1

FILE NO.: 00280.DWG F-36

REV	DESCRIPTION	DATE	BY	APP'D
01	PROTOTYPE RELEASE	08/29/94	LAM	





IMPACT DESIGN
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CLINTON, NJ 908/730-9669

MATERIAL: DELRIN

CUSTOMER: IRISCAN INCORPORATED

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ARE:

F[illegible]IONS	DECIMALS	ANGLES
±1/64	.XX±.01	±0.5°
	.XXX±.005	
	.XXXX±.001	

DRAWN BY: LAM	DATE 08/29/94	
CHECKED BY:		
ISSUED BY:		
FILE NO.: 00290.DWG		

TITLE: AXIS, OPTICS

SIZE:	DRAWING NO:	REV:
A	1300290	01

SCALE: 1 = 1   SHEET: 1 OF 1

F-37

APPENDIX G

ESTIMATED
DoD IRIS RECOGNITION SYSTEM
CORE SYSTEM COSTS
(PER PORTAL)

		ESTIMATED COST PRODUCTION QTY OF 1000 UNITS	
IRIS IDENTIFICATION VERIFICATION SYSTEM			
1. COMPUTATIONAL PLATFORM		$2,100	
- 486DX4 MICROPROCESSOR with 128 KByte CACHE			
- 640 X 480 X 8-bit MONOCHROME A to D IMAGE DIGITIZER			
- 8 M Byte DRAM MEMORY			
- 4 M Byte FLASH EPROM			
- TWO SERIAL PORTS/ COMM DRIVERS			
- SVGA /VIDEO OUTPUT ON BOARD			
	Sub-total		$2,100
2. IMAGE ACQUISITION MODULE			
- 1/3 " FORMAT MONOCHROME CCD BOARD CAMERA with 50mm LENS		$396	
- LIQUID CRYSTAL DISPLAY (LCD) MONITOR		$400	
- BEAM SPLITTER		$24	
- LUMINAIRE		$30	
- OPTICAL/ ILLUMINATION WINDOWS		$20	
	Sub-total		$870
3. ENCLOSURE			
- PLASTIC SHROUD/ OPTICAL FACEPLATE		$120	
- METAL ENCLOSURE		$500	
	Sub-total		$620
4. SOFTWARE LICENSE FEE (Paid to IriScan, Inc.) Cost per Portal/unit			$200
5. CENTRAL HOST COMPUTER ALLOCATION *** (Allocation based on total of 10 portals)			$190
		TOTAL PER PORTAL ESTIMATE	$3,980.00

CENTRAL HOST COMPUTER (OPTIONAL)	$1,050
32 bit Microprocessor, 486/DX40 MHz	
4 M byte non-volatile memory	
1.44 M byte Floppy Drive/ 340 M byte Hard Drive	
14 " SVGA color monitor	
Verticle case and 230 watt power supply	
101 enhanced keyboard	
PRINTER (ONE OF SEVERAL AVAILABLE LASER PRINTERS)	$550
SOFTWARE LICENSE (TYPICAL DISTRIBUTED SYSTEM FOR ENTRY/ACCESS CONTROL)	$300
TOTAL	$1,900

***

NOTE: The CENTRAL HOST COMPUTER is considered optional since the SOW required an estimate of the portal IV unit only. The Central Host Computer would be used when the system configuration required that the portal units be integrated with a central monitoring unit. If a Central Computer is required, the estimated cost would be prorated over the total number of portal units.

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